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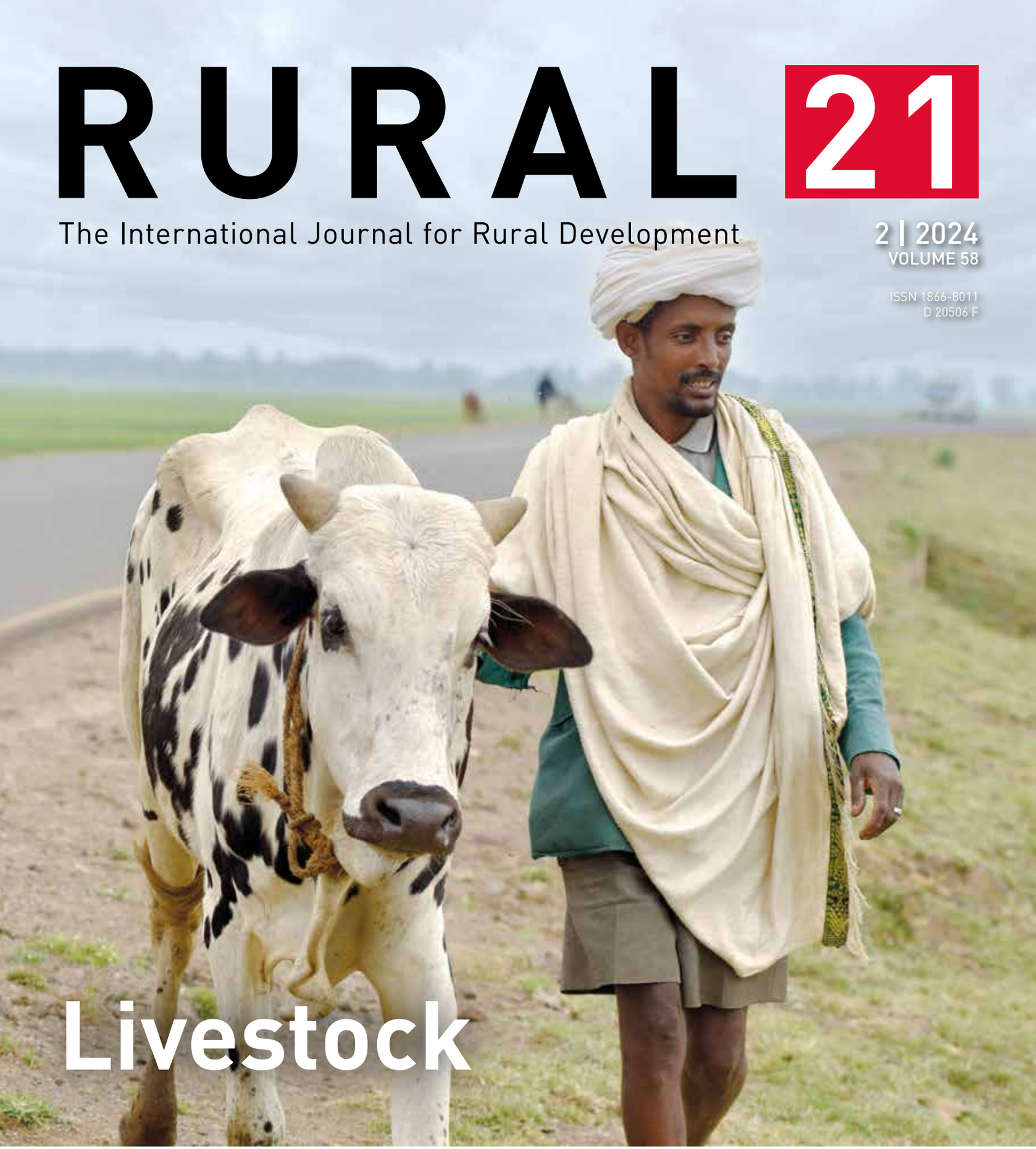

Livestock

AQUATIC FOOD SYSTEMS
Addressing post-harvest challenges

AFRICA
Improving soil health with alternative organic resources

AGROECOLOGY
Assessing the status quo of farm systems

rural21.com

Dear reader,

Regarding the transformation of our agricultural and food systems, hardly any sector has been as controversially discussed as livestock farming. Since the UN Food and Agriculture Organization report "Livestock's Long Shadow" in 2006 at the latest, it has been heavily criticised for harming the climate, and today, animal scientists mainly view the sector through the greenhouse gas emissions lens. This is not without reason, given that the livestock sector alone contributes roughly 47 per cent of the food systems' GHG emissions.

In the Global North, quite a few people would like to see animal products entirely deleted from the human diet – because this could reduce the emission of harmful greenhouse gases caused by enteric fermentation and land use change; because valuable natural resources such as land and water could be used more efficiently; because deforestation to create pastureland could be stemmed, which would protect biodiversity; and because, in many cases, they cannot reconcile animal husbandry with their animal welfare aspirations. And then there is the rapid growth of malnutrition and nutrition-related illnesses through excessive consumption of animal-sourced food, which has long also become widespread in the countries of the Global South, not to mention health risks such as the transmittance of zoonotic diseases.

However, agriculture without animals is simply not realistic. The issue here is not just that of producing food such as milk, eggs and meat, which represent an important source of proteins and micronutrients for many people. Wherever mechanisation is difficult to implement or is too expensive, draught animals continue to be needed for land cultivation, and so do animals as a means of transport. For women in particular, keeping small livestock such as goats or chickens is often the only option to earn their own income, and is hence key to economic and social empowerment – which is known to have a positive impact on their families' food and nutrition security as a rule. Furthermore, animals can serve as forms of saving, insurance and social security. And this, in turn, is also of particular significance regarding women, since they often lack traditional collaterals like land titles. In addition, for many people, keeping animals and living together with animals is part of their cultural and religious identity, which is why system-wide changes – as well as changes in dietary habits – are difficult to put into practice.

Yes, livestock farming does make use of around half of the world's agricultural land. But without animals, many of the world's regions could not provide food for people at all. A major share of the feedstuff that is not suitable for humans is turned into valuable food by animals. Rangelands offer important ecosystem services, including carbon storage and erosion control. Animals provide organic manure, which not only has a positive impact on soil health but also lowers dependence on (expensive) fertilisers. And they are an integral element of the urgently needed agro-ecological transformation, which is also based on the principles of the circular economy and (nutrient) recycling.

The United Nations has declared 2024 the International Year of Camelids, highlighting the importance of these animals – and hence also the importance of the pastoralist way of living – for food security and ecosystem functions. And it counters the attitude of governments in many African and Asian countries which regard traditional systems of transhumance as backward and sometimes pursue strict sedentarisation policies.

Knowing fully well that sustainable solutions for tomorrow's livestock systems always need a multi-faceted and context-specific lens, and that we have to deal with alternative protein sources anyway, all our authors ultimately back livestock farming. Let's see if you will too once you have read our magazine.

We wish you inspiring reading.

Patricia Summa Silvia Richter

Partner institutions of Rural 21

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African countries decide to tackle soil health challenges

Sustainable yield increases require healthy soils.

Photo: Paul Ohaga/ GIZ

Early in May 2024, the Africa Fertilizer and Soil Health (AFSH) Summit, organised by the African Union (AU) and the Government of Kenya, took place in Nairobi. About 4,000 participants, including over 60 African heads of state and ministers, policy-makers, the private sector, NGOs, academia and donor organisations, attended the summit to address pressing issues concerning fertiliser use and soil health. "A nation that destroys the soil destroys itself," declared Monique Nsanzabaganwa, Deputy Chairperson of the African Union Commission, quoting former US President Franklin D. Roosevelt, during the meeting.

In African countries, food insecurity and malnutrition have risen in the last ten years, as have dependencies on the global markets for food and fertilisers. The International Fertilizer Development Center (IFDC) estimated a production deficit of 30 million tons of grain in 2021. It sees the food supply of 60 to 90 million people at risk, especially in Mali, Burkina Faso, Tanzania, Zambia, Malawi, Mozambique and Zimbabwe. This is, *inter alia*, due to prolonged and widespread soil degradation. Many African soils are by nature heavily weathered, nutrient-poor and acidified. Unsustainable management practices and continuous under-fertilisation are the main reasons for severe nutrient depletion and reduced soil fertility, which result in low yields. The Russian war of aggression in Ukraine and the Corona pandemic have aggravated this trend, heavily impacting on the availability of and access to fertilisers. In the face of these challenges, the importance of sustainable fertiliser and soil management is becoming increasingly apparent.

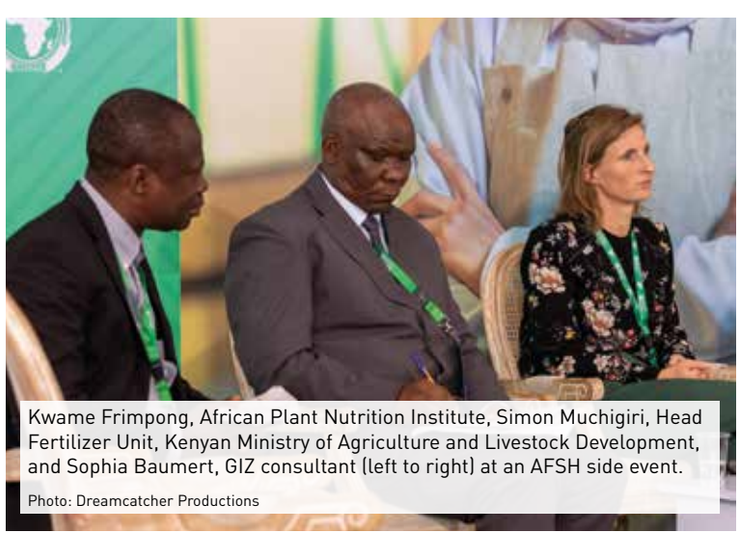
A clear paradigm shift

The Summit equally focused on improving fertiliser use and soil health from an integrated soil fertility management (ISFM) perspective. The ISFM concept comprises a set of soil fertility management practices, including the use of efficient fertilisers – both mineral and organic – and improved crop varieties, combined with knowledge on how to adapt the practices to local conditions. "A balanced approach to soil fertiliser management is critical," stated Nangolo Mbumba, President of Namibia. And Lazarus Chakwera, President of Malawi, added: "Even though our efforts to increase the access and use of inorganic fertiliser have led to an increase in our national agricultural output, the benefits have not been enjoyed by all as desired – the missing link is the urgency to address all soil health issues." This approach represented a clear paradigm shift from the Abuja Declaration on Fertilizer for the African Green Revolution of 2006, whose main objective was to increase fertiliser use to 50 kg/ha. As a result of the Summit, all 55 AU member states adopted the Nairobi Declaration, the 10-Year Action Plan on Fertilizers and Soil Health and the overarching Soil Initiative for Africa. These documents not only provide an important reference framework for future work on soil health and agricultural productivity in Africa but can support the sustainable transformation of agriculture and food systems, too.

The Nairobi Declaration aims to triple domestic production of organic and inorganic fertilisers by 2034 and to improve access and affordability for smallholder farmers. In addition, countries committed to reversing soil degradation and restoring soil health to at least 30 per cent of degraded soils within the same timeframe. The 10-year Action Plan translates the Nairobi Declaration into four outcomes with corresponding lines of action. Until the end of the year, the AU and its development agency AUDA-NEPAD plan to set up a secretary for pan-African coordination, support and monitoring of implementation. These processes shall be closely linked to the mechanisms of the Comprehensive Africa Agriculture Development Programme (CAADP) that is currently under revision. AU member states are supposed to draw up national action plans backed by appropriate funding until the end of the year.

Anticipating the AFSH Summit, the Economic Community of West African States (ECOWAS) and the World Bank hosted a round table on Fertilizers and Soil Health in May 2023 to strengthen soil health and improve the use of fertilisers as a key element in stimulating agricultural production and combatting food insecurity in West Africa, under the patronage of the President of the Republic of Togo, Faure Gnassingbé. The adopted Lomé Declaration can be seen as regional implementation framework for the Nairobi Declaration for West Africa. It remains to be seen to what extent other regional economic communities will join the coordination process to achieve the goals of the Nairobi Declaration and its 10-year Action Plan.

The third of the adopted summit documents, the Soil Initiative for



Kwame Frimpong, African Plant Nutrition Institute, Simon Muchigiri, Head Fertilizer Unit, Kenyan Ministry of Agriculture and Livestock Development, and Sophia Baumert, GIZ consultant (left to right) at an AFSH side event.

Photo: Dreamcatcher Productions

Africa, focuses on longer-term investments in soil science research to reach land users across Africa with the best practices, information and technologies available. The 10-year Action Plan is meant as first implementation phase of the Initiative.

To achieve its goals, the Nairobi Declaration specifically aims at fostering partnerships between various interest groups and investments in fertilisers and soil management to sustainably increase productivity in Africa. In this same spirit, 14 donors, amongst them the African Development Bank (AfDB), the European Commission, France, Germany, the Netherlands, Norway, the International Fund for Agricultural Development (IFAD) and the Bill & Melinda Gates Foundation, committed in their Joint Development Partner Statement to support the implementation of the Nairobi Declaration, the 10-year Action Plan and the Soil Initiative in a coordinated manner. "In Africa, for every one kilogram of fertiliser applied, we see 10 kilograms of grain," Enock Chikava, Director, Agricultural Delivery Systems at the Bill & Melinda Gates Foundation, stressed. "In America and in Europe, the same amount of fertiliser yields 30 kg of grain. This difference is what we call soil health. There is something taking place under our feet, and we need to correct it."

Together with its African partners, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH participated in several side events. The Kenyan Ministry of Agriculture and Livestock took the opportunity to present its agricultural and soil management policy, which was developed with the support of the Global Programme Soil Protection and Soil Rehabilitation for Food Security commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). Since 2014, through the work of the Global Programme, more than 600,000 smallholder farmers have applied sustainable soil management practices and have been able to rehabilitate more than 800,000 hectares of land. They have increased yields by an average of 33 per cent, directly benefiting the lives of over two million people.

Birthe Lappe, Christine Wolf, GIZ GmbH, Bonn

(See also article "Alternative organic resources for soil health in Africa" on page 49).

GLF Peatlands 2024: The climate solution we forgot

In the quest to combat climate change, we often overlook some of the most powerful natural allies available: peatlands. These unique ecosystems, found across nearly every country world-wide, have been under the spotlight at the "GLF Peatlands 2024: The Climate Solution We Forgot" conference in Bonn, Germany which was held in June 2024. With over 1,000 experts, practitioners, community members, scientists, and policy-makers in attendance, both in-person and online, the urgent need to protect and restore peatlands globally has never been clearer.

Despite covering only 3-4 per cent of the Earth's land surface, peatlands are the most efficient terrestrial carbon sink, storing up to 600 million tons of carbon in their soils – double the amount stored by all the world's forests combined. This remarkable capacity for carbon sequestration highlights their crucial role in mitigating climate change. However, when peatlands are drained or degraded, they release vast amounts of carbon emissions, contributing significantly to global warming. The experts at the conference warned that peatlands were disappearing three times faster than forests due to various human activities such as agriculture, forestry and peat extraction. This rapid loss not only threatens carbon sequestration efforts but also jeopardises the myriad of ecosystem services they provide such as flood and wildfire prevention, water filtration and biodiversity support. However, these ecosystems are of cultural and economic importance as well, especially for the indigenous communities that traditionally farm these areas sustainably. "Indigenous traditional land management practices and techniques should be recognised and acknowledged legally. We should promote and implement mutual and equal partnerships and collaborations, at both national and international levels, where indigenous communities are not just merely considered beneficiaries but the main actors," emphasised Emmanuela Shinta, Director of the Ranu Welum Foundation and Coordinator of the GLFx Kalimantan Chapter, in her presentation.

Protecting the remaining peatlands is a more straightforward and effective strategy compared to restoration efforts. Jochen Flasbarth, State Secretary at the Federal Ministry for Economic Cooperation and Development (BMZ), highlighted several lessons learned from both national and global experiences. "First, protection is better and usually easier than restoration," Flasbarth noted. "We need to act fast to protect the remaining peatlands both in Europe and world-wide. To reflect the true value of peatlands, they also need to play a stronger role in nationally determined contributions. Second, conservation and restoration will not work unless we include local communities and Indigenous Peoples. Third, public funds are an indispensable part of the solution. But we also need to find ways to engage the private sector in the sustainable use of peatlands."

Tropical mountain peatland degraded by livestock in páramo Almorzadero, Santander, Colombia.

Photo: David Rocha

The role of science and financing

Scientific research is pivotal in providing the evidence base for effective policy-making and implementation of peatland conservation strategies. However, there are still gaps in the definition and identification of peatlands, as well as in the mapping or exact condition of certain areas. For example, in Latin America and the Caribbean, reliable soil data and mapping was insufficient, making it difficult to estimate the extent of peatlands, said Kristell Hergoualc'h, a senior scientist in ecosystem functions at CIFOR-ICRAF. According to the experts, there was

At GLF Peatlands 2024 Conference, Sonya Sewi, Director of Asia at CIFOR-ICRAF, pointed out the major funding gaps.

Photo: Jörn Wolter

therefore a need for multisectoral and interinstitutional cooperation on a global level. The significant gap in financing for peatland restoration and management is another point that needs to be considered. Sonya Dewi, Director of Asia at CIFOR-ICRAF, pointed out that "the role of science is to provide an evidence base for policy-making so that the real benefits in terms of climate mitigation and livelihoods can be measured, planned and implemented well. The big gap is financing. Innovative financing would be a huge benefit to enable restoration and management for the benefit of climate and for the benefit of local communities."

Peatlands are a critical yet underappreciated component of the global ecosystem. Their unrivalled ability to store carbon, combined with the wide range of ecosystem services they provide, make their protection and restoration an urgent priority. Experts at the conference therefore made a strong appeal for global efforts around peatlands to be combined to protect and restore their true potential.

Patricia Summa, Rural 21

Advancing the human right to adequate food

This year's Policies against Hunger Conference, which took place in Berlin, Germany, early in June 2024, was dedicated to the topic "Twenty Years of Action: Advancing the Human Right to Adequate Food", referring to the 20th anniversary of the Voluntary Guidelines to Support the Progressive Realization of the Right to Food in the Context of National Food Security (Right to Food Guidelines). The conference was organised by the German Federal Ministry of Food and Agriculture (BMEL). Around 200 participants from 38 countries jointly discussed the successes and challenges in realising the right to food. "We need to join forces," said German Federal Minister of Food and Agriculture Cem Özdemir at the opening of the conference. Climate change, conflicts and wars are threatening the right to food. Hunger is on the rise and Sustainable Development Goal 2 (SDG 2) – Ending Hunger by 2030 – is far out of reach.

Eight per cent of the world's population are projected to be hungry in 2040, according to Maurizio Martina from the Food and Agriculture Organization of the United Nations (FAO). Martina pointed out that combating climate change and hunger often did not go hand in hand. "We have to make sure that both objectives are focused on. Fighting against hunger cannot be separated from fighting against climate change," he said. The global community had to do more to tackle the impact of climate change, especially on rural communities.

Right to food in times of war

"We cannot link humanitarian aid to political action," said Jochen Flasbarth, State Secretary at the German Ministry for Economic Cooperation and Development (BMZ). "We need to stay engaged, even with countries like Afghanistan with illegal governments." "The right to food remains paramount whether there is a conflict or not," added Nosipho Nausca-Jean Jezile, Chair of the Committee on World Food Security (CFS). The CFS endorsed the Right to Food Guidelines, which now serve as its basis, in 2004. Jezile referred to the dramatic situation in Gaza and Sudan, where access to food was damaged, as were access to produce food or access to prepare food.

Presenting the *From Arms to Farms* project, journalist and film producer Bernward Geier showed how conflict and hunger can be combated simultaneously. After decades of civil war between Islamic rebels and government troops, Mayor Rommel Arnado succeeded in pacifying his town of Kauswagan in the Philippines. A total of 24,000 people of Moslem or Christian faith live in Kauswagan and the 13 villages belonging to it. Rommel managed to get a few thousand combatants to swap their arms for land and training in organic farming. Geier reported that to date, 4,000 soldiers had surrendered their weapons and were engaged in organic agriculture. A school of organic agriculture had been established in the region, food security had been achieved for the population, and the area was now almost free from violence.

Seventy-five per cent of the extreme poor live in rural areas, and many of them are small-scale farmers. "They need assistance," urged Shantanu Mathur, Lead Adviser, Global Engagement and Multilateral Relations at the International Fund for Agricultural Development (IFAD), pointing out that longer-term development was extremely important in the fight against hunger. Small-scale farmers produce one third of the world's food. They need access to agricultural technologies. Fifty million people live in food insecurity in the Sahel, while millions of hectares of land are lost to degradation in the region each year. Dependence on food imports is high, Margot Van der Velden, Regional Director

Federal Minister Cem Özdemir opening the "Policies against Hunger" Conference in Berlin.

Photo: BMEL/ photothek.net

for Western Africa at the World Food Programme (WFP), reported. She named four points that are most necessary to tackle food insecurity: food assistance (which was often difficult to continue), investments in large-scale resilience programmes (focusing on soil as the foundation of food, like The Great Green Wall initiative), buying home-grown food and social protection programmes.

The case of Brazil

Just what successfully combating hunger can look like was demonstrated by the example of Brazil, of which Valéria Burity, Special Secretary of State for the Coordination of the Brazilian Zero Hunger Programme at the Brazilian Ministry of Social Development (MDS), gave an account. With its Fome Zero (Zero Hunger) programme, founded by President Luiz Inácio Lula da Silva in 2003, Brazil declared combating hunger and extreme poverty a government mission. Since then, it has scored remarkable success in this area. With the example of the Brazilian Council for Food and Nutrition Security (CONSEA), Professor Elisabetta Recine, CONSEA Chair, showed how participation can be successful. Set up in 2003, the Council was established at the level of the President of the Republic, and its objective is to advise the President. It is part of a national policy system.

CONSEA brings together the various aspects of food security and links civil society and the government. One third of the Council comprises government representatives (24 ministries), and two thirds are civil society representatives (farmers' organisations, human rights campaigners, etc.). The President always has to be a civil society representative.

School meals for food security

School meals can make an important contribution to food security. Here, participants of the conference discussed what had to be considered regarding sustainable and sensible implementation. "School meals are low-hanging fruit to improve school enrolment and healthy diets," said Fatima Hachem, Senior Nutrition Officer, Nutrition and Food Systems Division at the Food and Agriculture Organization of the United Nations (FAO). They contribute to children growing up to become educated and strong adults, Hachem maintained. But she also pointed out that school meals can have a negative impact on nutrition because they sometimes do not meet the necessary requirements for healthy food. In order to develop sensible concepts for school meals, it is important to adapt food volumes to the demands of different age groups and see to a balanced nutrient content. Furthermore, to support the local communities, local produce ought to be made use of. Food production has to be responsible and sustainable. "We must listen to those people who are hit hardest by poverty and food insecurity," said Claudia Müller, Parliamentary State Secretary, German Federal Ministry of Food and Agriculture (BMEL) in her closing remarks, stressing that the BMEL was seeking to use the Right to Food Guidelines as a guiding concept for its activities in support of smallholders. Food system transformation could only work if local structures were focused on, she said.

Ines Lechner, Rural 21

Rangelands in a worrying condition

Up to 50 per cent of the world's rangelands are degraded. This is one of the alarming facts published in the Global Land Outlook Thematic Report on Rangelands and Pastoralists, launched by the UN Convention to Combat Desertification (UNCCD) in May 2024. Symptoms of rangeland degradation include diminished soil fertility and nutrients, erosion, salinisation, alkalinisation and soil compaction inhibiting plant growth, all of which contribute to drought, precipitation fluctuations and biodiversity loss both above and below the ground. The problem is driven largely by converting pastures to cropland and other land use changes because of population growth and urban expansion, rapidly rising food, fibre and fuel demands, excessive grazing, abandonment (end of maintenance by pastoralists) and policies that incentivise overexploitation.

The rangelands category of Earth's land cover consists mostly of the natural grasslands used by livestock and wild animals to graze and forage. It also includes savannahs, shrublands, wetlands, tundra and deserts. Added together, these lands constitute 54 per cent of all land cover, account for one sixth of global food production and represent nearly one third of the planet's carbon reservoir.

Two billion people – small-scale herders, ranchers and farmers, often poor and marginalised – depend on healthy rangelands world-wide. Indeed, in many West African states, livestock production employs 80 per cent of the population. In Central Asia and Mongolia, 60 per cent of the land area is used as grazing rangelands, with livestock herding supporting nearly one third of the region's population. Ironically, the report underlines, efforts to increase food security and productivity by converting rangelands to crop production in mostly arid regions have resulted in degraded land and lower agricultural yields. The report calls out "weak and ineffective governance", "poorly implemented policies and regulations" and "the lack of investment in rangeland communities and sustainable production models" for undermining rangelands.

The report's 60+ expert contributors from over 40 countries agree that past assessing of degraded rangeland world-wide – roughly 25 per cent – "significantly underestimates the actual loss of rangeland health and productivity", which could be as much as 50 per cent. Rangelands are often poorly understood, and a lack of reliable data undermines the sustainable management of their immense value in food provisioning and climate regulation, the report warns, detailing an innovative conceptual approach that would enable policy-makers to stabilise, restore and manage rangelands. One core recommendation is to protect pastoralism, a mobile way of life dating back millennia which is centred on the pasture-based production of sheep, goats, cattle, horses, camels, yaks, llamas or other domesticated herbivores, along with semi-domesticated species such as bison and reindeer.

Halting the deterioration calls for a paradigm shift in management at every level – from grassroots to global, the report concludes. Achieving "land degradation neutrality" (Sustainable Development Goal 15.3) – balancing the amount and quality of healthy land to support ecosystem services and food security – also requires cross-border cooperation. Pastoralists with generations of experience in achieving life in balance with these ecosystems should help inform this process at every step, from planning to decision-making to governance, the report notes. Furthermore, solutions have to be tailored to the characteristics and dynamics of rangelands, which vary widely from arid to sub-humid environments, as seen in West Africa, India or South America.

(UNCCD/ile)

Photo: Zerihun Sewunet/ ILRI

Livestock and sustainable food systems – a complex relationship

Livestock production is more than just producing meat, milk and eggs. It provides many crucial services world-wide, particularly for small-scale and women farmers in the Global South. But these important services are often only insufficiently considered in the current debate on livestock's negative impact on the environment and climate, our authors claim. An overview of livestock's multiple roles and its intricate position in food systems – and a plea for context-specific and multifaceted approaches in developing sustainable solutions for tomorrow's animal husbandry.

By Nancy Bourgeois Lüthi, Martijn Sonnevelt and Angela Wade

Livestock systems, like any system, are made up of interacting components and are categorised according to specific criteria. Based on five such criteria, Seré and Steinfeld identified two types of livestock systems and four subtypes within four agroecological zones worldwide: 1) Solely livestock: 1a) landless or 1b) grassland-based, and 2) Mixed (crop-livestock) systems: 2a) in rainfed zones or 2b) irrigated zones. In these systems, livestock plays a key role, interacting with grasslands and croplands. Cropping and livestock practices can either preserve or alter the landscape, with potential positive or negative effects. Poor practices can threaten both the environment and its services and climate. Often, the negative impacts of livestock, supported by extensive evidence, are intuitively associated with high animal numbers and intensive and industrial farming practices. However, research also indicates that too few animals or low stock densities can be detrimental to the environment.

The adverse effects of livestock systems are not necessarily due to the presence of livestock itself, but rather to inadequate management that disrupts the agroecosystem balance. One of the major challenges lies in identifying root causes that harm agri-food systems, which include livestock production, and addressing them without causing further, more severe problems.

A look at climate change and natural resource consumption

Of the seven greenhouse gases (GHGs) targeted by the Kyoto Protocol, the primary GHGs emitted by the agricultural sector are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). In 2020, the global food system was responsible for 31 per cent of all GHG emissions caused by humans. Deforestation and enteric fermentation in ruminants are the top two sources of these emissions within the food system, accounting for 36 per cent of the food system's total GHG emissions. The livestock sector alone was estimated to contribute 47 per cent of the food system's GHG emissions in 2020 and 14.5 per cent of total global anthropogenic GHG emissions. Given that methane is a significant GHG with a higher global warming potential than CO_2 and a shorter atmospheric lifespan, the livestock sector is seen as a major lever to rapidly reduce GHG emissions from the food system, compared to other sectors.

Livestock and agriculture not only contribute to climate change but are also affected by it. Under the conservative scenario of 1.5–2°C temperature increase, it is estimated that 5 per cent of the world's livestock production (compared to 8 per cent for crops) will be outside the safe climate range by 2090. If temperatures increase by more than 2°C by 2090, 34 per cent of the world's livestock production (versus 31 per cent for crops) could be at risk. This will predominantly impact South and Southeast Asia, as well as sub-Saharan Africa, making vast areas currently suitable for livestock unsuitable.

Livestock is often criticised for its intensive land use, in competition with food produced for human consumption, its significant water footprint and its impact on biodiversity. However, a detailed examination reveals that while livestock uses about half of the world's agricultural land, this is mostly grassland, which is not easily, or not at all, convertible to crop land. Moreover, the livestock world diet is largely composed of feedstuff that is not suitable for humans. Similarly, it is important to note that over 90 per cent of the water used in beef production is rainwater, making it less reliant on irrigation compared to many crops, such as,


Photo: Stevie Mann/ ILRI


Photo: Stevie Mann/ ILRI


Photo: Camille Hanotte/ ILRI

for example, nuts. While there are instances where livestock compete with crops for land, the issues of water and land-use efficiency are complex. These examples illustrate that the role of livestock in agriculture cannot be addressed in a simplistic manner. Moreover, it has to be considered that livestock does not have a solely extractive role in agricultural and food systems: it contributes positively to the agri-food system and society in various ways.

A parameter with an important influence on livelihoods, nutrition and health, and ecosystems

Livestock offer a wide range of goods and services to humans. Approximately one billion people globally rely directly on livestock for their livelihood and food security. Animals and their products can be sold, traded or even used as collateral for loans and credit, serving as a form of savings, insurance and social security. While many livestock-related products and services are monetarisable, others, like risk mitigation for farmers – particularly in the Global South – are harder to value.

Livestock is the third most significant source of income for farmers world-wide, following crop and non-farm activities. For women in developing countries, especially those in poverty, small livestock is a crucial asset, enabling them to earn cash (also see article on pages 27–29). It is estimated that women make up two-thirds of the 600 to 800 million poor livestock keepers in the world. In many places, women lack access to traditional collateral like land titles, making livestock a key avenue for economic and social empowerment. Beyond providing material goods and services, animals hold significant religious or cultural importance in our daily lives. We see this in our food habits, rituals and ceremonies during important life events, such as births, entering adulthood, weddings and even funerals. These cultural dimensions can sometimes hinder efforts to bring about system-wide changes.

Animal-source foods have been part of human diets for millions of years. Livestock currently provide 18 per cent of global calories and 39 per cent of protein consumption. The consumption of livestock-derived foods varies across regions. At 69 kg/capita/year, meat consumption is highest in industrial countries with a high income and is lowest in developing countries, at 26.2 kg. Thanks to the high density, composition and bioavailability of their nutrients, these livestock-derived foods are well-suited for people with special nutrition needs and limited food-intake capacity, including pregnant women, young children and the elderly. However, excessive consumption of animal-source foods, especially in processed forms, contributes to malnutrition and health issues such as obesity, increased risk of cardio-vascular diseases and specific forms of cancer. Living close to animals and consuming animal products also entail further health risks, such as zoonotic and foodborne diseases. On the positive side, keeping animals, including livestock, can have beneficial impacts on mental health.

One global challenge is to reduce the consumption of livestock-derived foods in areas where it is in excess with regard to nutritional recommendations and increase it where it is in deficit. The UN Food and Agriculture Organization (FAO) sees several avenues to reach these goals, among others a reduction of the consumption of animal-source food and improved efficiency thanks to more productive animals.

Livestock directly contribute to plant production in several ways. First, animals provide manure, which enriches soil health. Second, in many Global South countries, livestock play a crucial role as draught animals for land cultivation. These direct contributions are essential for sustainable agriculture. However, there is also an indirect benefit: including temporary pasture in crop rotation enhances overall yields. This contribution is often overlooked when advocating for more plant-based diets.

Beyond cropping systems, livestock also have positive environmental impacts. Natural grasslands, covering a significant portion of the world's agricultural land, store substantial carbon. Proper grazing management, adapted to the local conditions and considering factors like stocking rate, adapted species and breeds, and timing, can prevent overgrazing, which lead to desertification, or under-grazing leading to bush encroachment and the risk of wildfires. Well-managed, natural grasslands offer additional important ecosystem services, including water regulation, erosion control and flood prevention, and support for diverse flora and fauna.

Addressing the trade-offs in livestock systems

The multifaceted aspects of livestock production reveal its inherent complexity and the trade-offs involved in addressing challenges.


Photo: CGIAR


Photo: Chi Nguyen/ ILRI

To tackle these issues, a systemic approach is essential. Here are some examples of systemic approaches currently employed, particularly in the Global South and, increasingly, worldwide, to navigate the complexities of livestock production.

Promoting integrated crop-livestock systems and circular economy

In the Global South, many smallholders continue to rely on integrated crop-livestock systems. These systems, once common in the Global North until World War II, face pressure to industrialise due to growing food demand, especially for livestock-derived foods, particularly in the Global South. To enhance food system efficiency, we can reconnect crop and livestock production at farm, local or regional levels. By using crop residues and by-products from the agri-food industry as feedstuff, or manure as fertiliser and energy production, as well as through optimised natural feeding practices, we can simultaneously benefit humans and respect planetary boundaries. Adopting (again) a circular approach and reviving agroforestry systems offer promising avenues for sustainable transformation of food systems.

One Health

The concept of One Health, championed by the World Organisation for Animal Health (WOAH), applies a systemic approach. It bridges disciplines, involves various stakeholders and integrates the various dimensions of livestock management by considering their impact on human, animal and environmental health. This approach has been successfully employed in many countries to combat antimicrobial resistance (AMR) across humans, animals and agriculture.

True cost accounting

True cost accounting of food offers a way to shift food purchasing and consumption habits. It involves assessing and monetising the full spectrum of costs related to food production and consumption: economic, environmental, social and health impacts. However, true cost accounting still faces limitations, particularly in accurately accounting for carbon stocks and soil organic build-up.

Collaboration is key

The transformation of our food system is essential for resilience, sustainability and inclusivity, while respecting Earth's boundaries and ecosystems. Simultaneously, we must enhance food system efficiency to improve and ensure global food security. Among the critical components, the livestock sector – alongside agriculture, food processing and logistics – plays a pivotal role. It supports livelihoods, health and nutrition for people and ecosystems.

However, challenges lie ahead. We must move beyond current blueprints and simplistic approaches, addressing inevitable trade-offs. Achieving a systemic understanding of the food system – its trade-offs and interdependencies – requires research and development efforts from both public and private entities. These efforts should focus on sustainable production systems and supply chains applicable within the given context.

Market demand acts a decisive force. Raising consumer awareness about health, social, economic and environmental issues is crucial. Predictable and fair market mechanisms, guided by transparent regulatory frameworks, empower all food-system actors. This calls for coordinated measures by public and private entities.

Collaboration among diverse stakeholders is key. No single actor can transform food systems alone. Multi-stakeholder platforms, initiatives and networks globally drive change. Recommendations from these platforms must inform global guidelines, national policies, industry standards and educational programmes. Yet, the policy environment matters most. Supportive governance structures, breaking down sectorial silos and evidence-based decision-making fuel food system transformation. Together, we can achieve sustainable food systems and progress towards the 17 Sustainable Development Goals.

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A sector in transition

Livestock production has seen a huge increase over the last three decades, with global demand for meat alone growing by around a third. Our authors outline key trends in livestock production and consumption, finishing with a brief discussion the ways in which livestock can contribute to sustainable food systems while at the same time enhancing the food security and well-being of people depending on them for their livelihoods.

By Mario Herrero and Philip Thornton

One of the main messages of the COP 28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems, and Climate Action in late 2023 was that to fully achieve the long-term goals of the Paris Agreement, agriculture and food systems have to be included if we are to meet the Sustainable Development Goals (SDGs). We need to use land more sustainably, minimise negative impacts on the environment and seek for opportunities to restore lands that have lost nutrients and biodiversity. At the same time, food systems have to provide all people with access to a more nutritious diet. Taken together, this is a big ask of future food systems, given the growing demand for food from rising populations and a warming, more variable climate. The livestock sector is an important contributor to both the challenges and the solutions. On the one hand, it is a major user of land and emitter of greenhouse gases, but on the other, it provides food with high quality protein and high levels of micronutrients, as well as incomes and livelihoods for hundreds of millions of people, particularly in lower-income countries.

A herd of Nelore cattle in Mato Grosso do Sul, Brazil. Beef demand in the country is growing.

Photo: Erich Sacco/ shutterstock. com

Livestock production has been growing rapidly in response to increasing demand. The livestock sector now has considerable impacts on global biogeochemical cycles and is a substantial user of water as well as causing losses in biodiversity. Reducing the environmental footprint of livestock is vital if it is to contribute to sustainable food systems in the future. The sector is highly dynamic in relation to its use of natural resources and the trade between countries and the synergies and trade-offs associated with the changing nature of the demand and supply of animal food from cattle, sheep, goats, pigs and poultry.

Trends in livestock product consumption and trade

Changes in consumption of livestock products from 1990 to 2015 for the regions of the world and selected countries are shown in the Figure on page 14. These trends have continued since; the last 35 years have seen an increase of about 35 per cent in per capita demand for meat across all regions, driven by large increases in demand for poultry and pork. Global demand for beef and mutton, in contrast, has barely changed since 1990, with declines in beef demand in high-income countries and Latin America (excluding Brazil) and large increases in China, Brazil, and Western Asia and North Africa. These regional patterns for beef apply to mutton, too. Per capita demand for poultry meat has increased in all regions, with small increases in East Africa and the USA and a near doubling in other regions. Demand for pork is regionally variable, with substantial increases in China, Southeast Asia, South America, and Australia. In lower-income countries, increased meat demand is mostly from pigs and poultry. Higher-income countries have seen substantial substitution of beef and mutton with pork and poultry. Demand for dairy products is growing at a similar rate to pork, with most regions seeing increasing demand.

The increase in consumption in some countries has outstripped supply, leading to substantial increases in international trade in animal-source foods in recent decades. The value of exports has quintupled since 1990 to more than 300 billion US dollars (USD), representing almost 20 per cent of global production. Globally, meat dominates, accounting for about two thirds of the value of exports of livestock products. In Europe and Oceania, however, the value of the trade in dairy products and eggs is equivalent to that of meat. These two regions export 85 per cent of the global volume of these commodities. Europe (primarily pork), North and South America (beef, pork, and poultry) and Oceania (beef and mutton) produce more than 90 per cent of global meat exports.

Some of the trade in meat is within the same region of origin; for instance, a large proportion of the trade in pork in Europe and in mutton in East Asia and Pacific is intraregional. There are countries which dominate trade between continents, such as Brazil, Australia and USA, for example, regarding inter-regional bovine meat exports. With respect to vol-

ume, trade in livestock products is small compared with trade in animal feed. For example, trade in meat and processed meat account for less than ten per cent of the volume of trade in feed grains. The trade in feed is likely to intensify, to satisfy the rising demand for pork and poultry in importing regions. This may result in growing environmental impacts, which will need to be mitigated appropriately.

Trends in livestock production

Meat, milk and eggs are produced across most of the major agroecological zones of the world, with a wide range of intensification levels and resource use efficiencies. Livestock numbers closely track demand trajectories. Since 1990, the global tonnage of meat, milk and eggs produced has increased by slightly less than two per cent per year. This has occurred in all regions, with particularly high production increases in Africa and Asia. In higher-income regions, production has grown at a slower rate, and in Europe it has declined by more than 16 per cent since 1990. Across the commodities the fastest growth in production has been for poultry meat, which has more than tripled globally since 1990. Egg production has more than doubled, and pork and dairy production have both increased by 80 per cent. As for poultry, egg and pork production has risen across most regions. In lower-income regions, dairy production has grown at a similar rate to poultry, with much smaller growth rates in higher-income regions (and a decline in Europe). Europe's beef and lamb production roughly halved from 1990 to 2022, whereas lower-income regions have seen substantial growth in small ruminant production.

Production efficiency gains have often been associated with intensification, which has occurred at different rates in different parts of the world. In some cases, this has led to a reduction in animal numbers. For instance, the USA produces 60 per cent more milk with 80 per cent fewer cows now than in the 1940s because of improvements in genetics, feeding and housing systems. Intensification (and expansion) of the livestock sector has occurred primarily in Latin America and Asia. By contrast, productivity in sub-Saharan Africa has remained essentially stagnant.

Different production systems, different dynamics

Most bovine milk and meat production takes place in mixed crop-livestock systems: 90 per cent of the milk and 80 per cent of the meat, with three times the number of animals, compared with grassland-based systems. Globally, observed increases in production have been driven mostly by increases in animal numbers. On average, livestock systems in temperate regions and higher-income countries have seen a four per cent per year decrease in animal numbers, while maintaining modest productivity increases of under one per cent per year. In arid and humid regions and many lower-income countries, by contrast, production increases have been driven almost entirely by increases in animal numbers. It is only the highland production systems of lower-income countries such as in Kenya and Ethiopia that have bucked this trend: increases in dairy productivity (28 %) outstripped the growth in animal numbers (9 %) between 2000 and 2011. Given the fact that the highland small-scale dairy production systems have been a major focus of research and extension efforts over the last 30 years or so, this is not that surprising.

Soy harvest in Brazil. Trade in feed is likely to intensify, to satisfy the rising demand for pork and poultry in importing regions.

Photo: Fotokostic/ shutterstock.com

Future role of smallholders in producing livestock products

Globally, livestock production is the mainstay of about 650 million people in lower- and middle-income countries. Livestock contribute 17–47 per cent of the value of agricultural production nationally and provide income to 68 per cent of lower- and middle-income country households, while also playing important cultural roles. Although there are wide regional variations, men are often responsible for cattle and cattle production, with women tending to be more active in raising small stock and in the processing and sale of products such as eggs and poultry. The contribution of livestock production to gender equity differs widely.

The future role of smallholders in producing livestock is highly uncertain and will depend on species and product. For dairy production, a sustainably intensified smallholder sector could help drive future production growth; there are still large yield gaps in these systems, and demand is growing. On the other hand, land fragmentation and feed scarcity may militate against continued viability of these systems in many lower-income countries.

The situation is different for beef. In the absence of increases in demand per capita, and with small farm output largely dependent on increased numbers of animals, size of operation will likely constrain production growth. Nevertheless, small-scale production in diversified farming systems may continue to be economically viable, even if not as the main source of income. For poultry and pigs, the distinction needs to be made between the rapidly growing industrial sector and the smallholder sector in which women are strongly represented. As economies grow, smallholder pig and poultry production may become less important as conditions become more favourable for the sector to industrialise.

Livestock production, land use and the environment

Of the 3 billion hectares (ha) of land suitable for crop production, 1.5 billion ha is used to feed the world, and a third of that is used to

produce feed for livestock. The remaining 1.5 billion ha is currently occupied mostly by forests, which play a fundamental role in biogeochemical cycles and provide many essential environmental services to humanity. Expansion of croplands into these areas needs to be avoided, hence the pursuit of agricultural intensification. Globally, total agricultural greenhouse gas emissions have risen, mostly due to increases in animal numbers and land-use change. Livestock account for the majority of greenhouse gas emissions from food systems through methane from enteric fermentation, CO_2 from land use change, and nitrous oxide from manure management. Despite productivity improvements, the aggregate environmental impacts of livestock have continued to grow.

Livestock production affects biodiversity beneficially or detrimentally, depending on context: while livestock-induced land use conversion is a major cause of biodiversity loss, in extensive rangelands ruminant livestock can be an important means of biodiversity conservation and climate mitigation. Resource use varies widely by commodity type. Beef cattle tend to be the largest user of land and energy, followed by pork, poultry, eggs and milk. Resource use also varies by production system and setting. In many cases, livestock can be reared in lands of low opportunity cost, without competing with croplands or other land uses. Any intensive livestock production system has significant environmental impacts, especially for surrounding communities and waterways, and these have to be addressed.

What next for livestock product consumption?

The evolution of the global livestock sector over the last 30 years can be outlined in three storylines. First, demand for poultry has been the main global driver of increased meat consumption, with a near doubling of per capita consumption since 1990. Second, per capita dairy consumption in higher-income regions has stayed constant since 1990, production growth being driven by population growth. Lower-income regions have seen significant increases in dairy consumption, driven by both population growth and increased per capita consumption. Third, increases in global beef demand is largely down to China and Brazil, which account for nearly 93 per cent

Change in animal-source food demand 1990–2015

	Fish, Seafood	Milk – excluding butter	Eggs	Meat	Bovine meat	Mutton & goat meat	Pig meat	Poultry meat
Europe	4,5	25,2	0,6	1,8	-8,8	-1,4	0,8	10,6
Northern Africa	8,7	47,8	1,3	12,2	3,3	1,9	0,0	6,5
Western Africa	6,8	6,6	0,3	2,8	0,2	1,2	0,4	1,6
Eastern Africa	-0,9	17,3	-0,1	0,5	-0,2	-0,1	0,4	0,4
Central Africa	3,6	-5,5	0,4	8,4	-1,1	0,4	2,2	7,2
Southern Africa	-1,9	8,4	3,3	23,2	-1,2	-1,1	2,4	22,3
Eastern Asia	19,0	29,7	11,2	35,7	3,9	2,2	18,2	10,4
China	24,1	35,6	13,0	38,8	4,6	2,6	19,5	11,1
Central Asia	0,7	44,1	2,2	9,2	1,7	-0,5	2,0	5,4
Southern Asia	3,0	34,8	1,4	1,4	-0,5	-0,5	-0,2	2,6
India	2,0	35,3	1,6	0,2	-1,2	-0,1	-0,2	1,7
South-Eastern Asia	17,0	7,6	2,4	16,6	1,3	0,2	7,5	7,6
Western Asia	2,0	7,4	0,9	16,1	2,2	-1,4	0,1	15,4
Americas	0,9	12,3	2,9	19,2	-0,8	-0,2	1,5	18,6
USA	0,5	-3,6	1,1	5,8	-5,8	-0,3	-1,6	13,4
South America	2,0	33,4	2,7	31,2	3,8	-0,3	3,9	23,9
Brazil	4,7	57,0	1,1	44,0	11,8	-0,2	4,2	28,1
Oceania	8,2	-30,6	-2,1	7,6	-6,6	-13,6	6,5	22,4
Australia	9,1	-17,4	-1,5	6,9	-6,5	-13,9	6,2	23,0
World	7,0	18,9	3,1	11,3	-0,6	0,2	3,3	8,1

Change in kg per person per year between 1990–2015

- 60 ... + 60

Source: Herrero et al. (2021), see: doi.org/10.48565/bonndoc-1

Demand for poultry has been the main global driver of increased meat consumption, with a near doubling of per capita consumption since 1990.

Photo: Evgeniy Kalinovskiy/ shutterstock.com

Egg production and sale tends to be in the hands of women.

Photo: Jörg Böthling

of the 11 million ton (Mt) increase in global beef demand.

Recent trends indicate that projected shifts to beef consumption as incomes rise may not be occurring in many countries. Indeed, in many higher-income countries, beef consumption is declining; this is particularly obvious in Europe, which saw a reduction of more than 10 Mt in beef demand since 1990. Excluding China and Brazil, per capita consumption in low- and middle-income countries has not increased appreciably. Reasons for this may include a combination of factors. In recent years, pork and poultry have been cheaper than beef by 50 per cent and 30 per cent, respectively. Increased messaging around the health and environmental impacts of beef consumption compared with white meats may also be having an increasing influence on consumer behaviour.

Contribution of sustainable livestock production to future food systems

Highly divergent future visions of the livestock sector can be found in the scientific literature. These include a business-much-as-usual world with continued (and considerable) increases in demand and consumption of livestock food, a world of techno-optimism that envisages widespread uptake of alternative protein in human diets with substantial declines in demand for livestock meat and milk, and a world that sees substantial declines in human consumption of livestock food and a move to more plant-based diets. Local, national, and regional contexts matter enormously, in terms of how the livestock sector may develop in different places in the future. Livestock development will be shaped by a host of factors, but some can be taken as effectively immutable to mid-century at least: the enormous economic and sociocultural value of livestock in many lower-income countries, the considerable disruption and loss of value to industrial and small-scale livestock systems alike that climate change will bring about in many places, and burgeoning demand for livestock products from growing and urbanising populations, particularly in Africa.

Different contexts will shape the nature of livestock development in different places, and livestock systems will evolve in many different ways in parallel. Changes in dietary preferences, alternative proteins for food (also see article on pages 37–38) and feed, practices that help to mitigate greenhouse gas emissions, sustainable intensification of livestock production revolving around the principles of circularity, adopting appropriate technological innovations, putting in place policies that can spur climate action in agriculture, repurposing subsidies that distort level playing fields for trade to incentivise climate action and move towards true cost accounting for the food system – these are some of the many ways in which livestock can contribute to sustainable food systems in the future. Implementing the most effective and desirable solutions will be essential for balancing stakeholders' economic, social and environmental goals in different contexts. Underlying all this is improved understanding of the highly variable roles that livestock play. This is fundamental to implementing actions and policies that profoundly improve and, in many cases, may substantially change the ways in which we think about livestock.

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The animals kept by pastoralists are multi-functional and provide a range of products and ecological services. Photo: Ilse Köhler-Rollefson

Learning from pastoralists

There is an enormous backlash against animal farming. But from the perspective of food security and agroecology, a world without livestock is hardly feasible. Our author maintains that, instead of demonising the sector because of its negative environmental impact, one should look to pastoralists to see how livestock systems can be designed in such a way that they adhere to planetary boundaries.

By Ilse Köhler-Rollefson

"Planetary Boundaries" is a concept that defines the environmental limits humanity can safely operate in without risking interfering with the regulatory processes of the planet. A team of scientists led by Swedish scientist Johan Rockström identified nine processes that keep the Earth in balance. They relate to land use change, ocean acidification, climate change, freshwater use, biosphere integrity, biochemical flows, novel entities, and others. It is a rather complex framework, but is much more specific and practice-oriented than "Sustainability", which has become almost meaningless given its universal application without concrete definition. In the livestock sector, sustainability is largely being gauged by greenhouse gas (GHG) emissions per product unit, which ignores impacts on key facets of planetary boundaries, such as biodiversity, land use change, freshwater use, biochemical flows, etc. Livestock certainly plays a huge role in whether human activities remain within planetary boundaries. Since 1961, the earliest year for which the United Nations Food and Agriculture Organization (FAO) has recorded data, the world's livestock numbers have increased exponentially, vastly outpacing human population growth. In the 60 years between 1961 and 2021, poultry populations increased by 700 per cent, goat and camel numbers tripled, pig numbers grew by 250 per cent, and buffalo numbers doubled. The growth of poultry and pig populations has only been possible because of the global trade in livestock feed that enables industrial livestock production units to be set up without regard for the local availability of feed. This is now grown in the form of monocultures of soy, corn and alfalfa in one part of the world (the Americas) and transported to other continents such as Europe, the Middle East and Asia, whose livestock population growth could otherwise not be supported. This expansion leads to deforestation in the Amazon (and elsewhere) and associated biodiversity loss, and goes along with an increased danger of novel diseases emerging.

At the receiving end, the monocultures of animals in industrial settings may produce animal protein cheaply, but they are accompanied by a multitude of negative impacts on the environment in terms of soil, air, and water pollution, by the use of antibiotics and ensuing antimicrobial resistance, and of course, by a serious lack of animal welfare. Apart from that there is the issue of GHG emissions, which currently seem to be the dominant focus of livestock research.

Despite the enormous impact that farm animals have on the Earth's regulatory processes, as first collated in its 2006 "Livestock's Long Shadow" report, the FAO states that livestock output needs to double by 2050. At the same time, there is an enormous backlash against animal farming, with young people being attract-

ed by veganism, and corporate interests utilising this scenario to develop imitation livestock products of questionable environmental impact and nutritional value while pushing for the total elimination of livestock from the planet by 2040. Several UN agencies have joined this bandwagon. Recently, to reduce nitrogen emissions from manure and fertiliser, the Dutch government has come forward with a plan to close more than 10,000 farms and reduce the size of 17,000 more, a move that has understandably led to wide-spread protests.

An ecological necessity for a functioning planet

But a world without livestock is unrealistic from the perspective of food security and agroecology. We must realise that only one third of the world's agricultural land is classified as arable, i.e. suited for crop cultivation, while in roughly two thirds of it, food can only be produced by means of livestock converting the existing inedible plant mass into edible animal protein and fat. In addition, even in fertile areas where crops can easily be grown, livestock is necessary to uphold the circulation of nutrients into the soil and decrease the amount of chemical fertiliser. In fact, the separation of crops and livestock is ecologically disastrous, and they need to be re-integrated as much as possible to recycle nutrients.

Rather than aiming to eliminate livestock, the challenge is to transform the livestock sector so that it is in balance with the Earth's resources and buffers against climate change rather than accelerating it. In this respect, we can learn much from pastoralists who specialise in keeping diverse types of livestock, such as reindeer in the Arctic, yaks in Asia's high-altitude zones, Bactrian camels and dromedaries in the deserts of Asia and Africa, cattle, sheep and goats in the semi-arid steppes and savannahs of Africa, and llamas and alpacas in the Andes in South America. We tend to think of pastoralism as a minor and marginal phenomenon, but it covers a far greater share of the globe than sedentary farming. A galaxy of herding cultures manages around 40 per cent of the world's landmass, an area about three times larger than that cultivated with crops (also see pages 20–21).

A solar-powered, biodiversity-conserving way of food production

For pastoralists, the starting point of their considerations and planning is the availability of plant biomass – be it natural vegetation or crop aftermath – that is available within walking distance of their animals. The rationale of their system is to deploy herds to harvest these resources, whether they are in high altitudes, thinly dispersed in remote areas or growing on roadsides, or on empty plots in urban areas. To this end they require animals that are physically fit and can walk over long distances, that thrive on whatever grows in a particular region, withstand inclement weather and can slow down their metabolism to cope with seasonal shortages. Their breeds retain characteristics of their wild ancestors by being tough and resilient. But unlike their untamed predecessors, they tolerate and even relish proximity to humans. In herding societies, people and animals are bound together in a relationship of mutual dependence and trust.

Pastoralists adhere to planetary boundaries by utilising only what is already available and would otherwise go to waste, either provided by nature or left over by farmers. They do not spend energy on growing feed, and animals walk to their forage. Their system is basically solar-powered. It is fossil fuel-free and does not add any CO_2 to the atmosphere. Whereas crop farmers destroy biodiversity by replacing native vegetation with monocultures and routinely deploying chemical fertilisers, pesticides and other -cides, pastoralists do none of this, directly converting a multitude of foraging plants into human-edible protein. Herding mimics the ecological role of wild herbivores by upcycling biomass for consumption by predators and carnivores, and by recycling nutrients into the soil. In view of the fact that the planet's wild fauna has been reduced by more than 90 per cent, some experts think that herded animals are essential to uphold the functionality of the planet and contribute to its cooling.

There is no doubt that herding animals is absolutely the most natural way of food production that exists, which is of enormous relevance at this point in human history. The need to reduce emissions from agriculture has been agreed upon as a priority during the COP 28 (Conference of the Parties to the UN Framework Convention on Climate Change) in late 2023 in Dubai. In FAO's own words, we need agrifood system solutions that build resilience, adapt to climate change, and reduce emissions while safeguarding biodiversity and ensuring food security for all. No other agrifood system fulfils these requirements as well as pastoralism.

The first step for keeping livestock within planetary boundaries is a paradigm change

In animal science, sedentary livestock keeping is the default model. The focus of the discipline has been on improving efficiency in terms of feed to food conversion. At a superficial level, this concept makes sense since it seeks to minimise the use of resources, is most economical, and results in smaller amounts of GHG emissions per unit of product. Unfortunately,

In herding societies, people and animals are bound together in a relationship of mutual dependence and trust.

Photo: Jörg Böthling

it is also reductive and ignores the crucial aspect of recyclability of resources as well as the other positive and negative impacts that animal farming has on biodiversity, soil, water, air, livelihoods, public health, and animal welfare.

If we use "efficiency" as the only yardstick for evaluating livestock systems, then concentrated animal feed operations come out on top despite their multitude of negative impacts, while animal welfare-friendly grazing systems that sequester carbon and enhance biodiversity fall behind. In our current scenario, we can no longer afford this simplification and must articulate a new theoretical framework for livestock development that takes the complexity of the situation into account and figures in all the positive and negative aspects or trade-offs of farming animals. Only then will we be able to design systems that stay within planetary boundaries. This new paradigm must consider animal well-being, use of fossil fuels, impact on biodiversity, soil, water, air pollution, the nutritional content of animal-sourced food and, especially, livelihood impacts, and public health.

The current 'efficiency paradigm' has contributed to and provided scientific justification for the rise of industrial animal farming. It has played into the hands of the oligopoly of corporate giants that currently control the flow of feed and animal genetic resources across the globe. It has disadvantaged the estimated 400 million to one billion of herders and small-scale livestock keepers who use local livestock to optimally utilise the limited resources in their respective environments and convert them into high-value protein, and whose livelihoods depend on livestock.

Currently, GHG emissions are the dominating lens through which animal scientists view livestock, and much research effort is devoted to measuring and reducing methane emissions, even in poorer countries who have historically not contributed to global warming and where grazing animals are the backbone of rural economies. Of course, ruminant livestock, be it sheep, goats, cattle, camels, the South American camelids, yaks, buffaloes or even reindeer, all do emit methane. But so do giraffes, elephants, buffaloes and all the many antelopes that roam around in Africa's savannah, or their relatives in Asian steppes. As Spanish researcher Pablo Manzano has pointed out, if we were to remove livestock from grasslands and drylands, wild ruminants and termites would move into the vacated space, making this basically a zero-sum game in terms of methane emissions.

Lessons from pastoralists

It may seem far-fetched to look to pastoralists for guidance when designing livestock systems for the future, considering the lack of space and the hectic scramble and grab for the remaining open land. Nevertheless, we can extract certain principles from the art and science of pastoralism that we should integrate into other systems of livestock production as much as possible to make them more environment- and animal-friendly.

Movement. The first principle is to keep livestock moving. This has two main benefits. It keeps animals healthy and saves fossil fuels. And it is in line with nature. Movement is what distinguishes animals from plants. While plants can directly convert sunlight into energy by means of photosynthesis, animals do not have that facility. To live and reproduce, they must move to the plants to obtain energy. Unfortunately, over the last century or so we have reversed this design principle and keep animals in fixed locations while moving plants to them. We need to reverse this and focus on making best use of the biomass that is locally available, either naturally or as crop by-product, without expending fossil fuels on growing it.

Multifunctionality. Livestock breeding has become too specialised, concentrating on one product only, i.e. milk, meat or eggs, which involves a huge waste of resources in the form of male animals that have no purpose. Pastoralists have animals that are multi-functional and provide a range of products, such as meat, milk, manure and skins as well as ecological services. The principle of multifunctionality should not only be applied to animals but also to land use. Livestock production can easily be integrated with green energy, with landscape enhancement, crop, forest management, recreational uses, etc.

Diversity. Thirdly, we need a diversity of animals that fit varied eco-systems and are robust and resistant to the spread of diseases. We need to counter the ongoing loss of animal genetic resources and get policy-makers to understand that high yielding Holstein-Friesian cows are not a panacea for rural development, but often turn into a burden and debt-trap. Locally adapted animals are easier and cheaper to manage.

Circularity. Fourthly, we need to design circular livestock systems in which nutrients are recycled and manure is an asset that upholds soil fertility rather than representing a toxic mass that pollutes groundwater and water bodies, besides fouling the air. Re-integration of crops and animals is called for, and crop and animal scientists must interact and not work in isolation.

Quality. Fifthly, there needs to be more focus on the quality of livestock products rather than on their quantity, an aspect which is currently ignored. The products from animals grazing or browsing on biodiverse vegetation are vastly different from those fed on concentrate and standardised diets. When animals ingest feed rich in phytochemical substances, this has impact not only on the animals but also on the humans who eat them.

Decolonising animal science

Governments almost everywhere have sought to stop herding, blamed it for environmental destruction, and declared it dead. This is to a big extent, the consequence of the colonial era when agricultural concepts of settled farming that originated in the temperate climates of the colonisers were instituted in countries with significant populations of mobile pastoralists, for instance in India. But herding is still very much alive; although struggling, it is showing enormous resilience under human-made adverse conditions as well as climate change. And it is experiencing a change in fortune. Development agencies seek to revive mobile livestock keeping, beginning to extract lessons from pastoralism for coping with climate change. Transhumance, the movement between summer grazing in the highlands and winter pastures in the lowlands, has been declared UNESCO intangible cultural heritage in more than ten different countries. In the USA, regenerative and conservation grazing are rapidly gaining steam. We need a new way to look at livestock that recognises mobility as a key feature of ecological and animal welfare-friendly animal farming!

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References: **www.rural21.com**

Pastures benefit cattle welfare and product quality

Grazing ruminant systems serve as a basis of livelihood for households in large regions world-wide, but have been abandoned in industrialised agriculture. In ecological and climate-related debates, they are viewed as both a solution and a misconception of livestock production. Against this background, this article spotlights the opportunities grazing provides to unifying ecological, animal welfare and product quality requirements.

By Florian Leiber

By their digestive physiology, ruminants are world champions in degrading, utilising and converting fibrous plant material into human edible protein. No doubt, this was the reason for their domestication and millennia of herding cultures in grassland and rangeland regions all over the globe. They provide food from a resource which is otherwise hard to utilise by human production activities. But this is not all. Over long periods of time, herding has significantly contributed to the formation of black soils, landscapes and pastureland ecosystems. Today, stocking pastureland is absolutely crucial to the conservation of biodiversity, soils and below-ground carbon stocks. Both abandonment and overstocking have severe detrimental effects on these values. Nevertheless, both happen, with a strong tendency towards abandonment in industrialised and overstocking in smallholder agriculture.

Multispecies swards give ruminants the opportunity to select or avoid plants, thus allowing them to balance their own digestive metabolism and health. Photo: Kurt Graf

Selection is meaningful behaviour

However, besides multiple synergistic ecosystem services, grazing, in particular of natural pastures, can bring along welfare and health benefits which add to the value of utilising the resource. Herbal plants as well as shrub and tree leaves contain manifold phytochemicals like tannins, essential oils, alkaloids, etc., which impact the microbial fermentation of the feed in the ruminant's forestomach. Selecting or avoiding plant parts containing such active substances provides an opportunity for the animal to steer its digestive fermentation, therewith optimising the amounts of beneficial omega-3 fatty acids, antioxidants and vitamins, the efficiency of feed protein utilisation and much more. Moreover, broad research evidence exists that ruminants are able to choose plants with phytochemicals targeted to heal parasitic diseases or bind poisons like mycotoxins in their digestive tract. The higher botanical biodiversity is, the greater the animal's opportunity for choice.

Increased omega-3 levels in ruminant products from biodiverse pastures are evident, and the physiological mechanism behind this is that phytochemicals protect these fatty acids from too frequent microbial modulation in the forestomach. The health value of omega-3 is relevant not only for human consumers but also for the animals themselves – since we are all mammals with a similar metabolism. The importance for the animal itself is the link to selection behaviour: it is not acting by chance but by targeted balancing of its own digestive metabolism and health. Driven by desire and aversion for tastes and odours, this behaviour has been successful for 30 million years, when the first forms of ruminants developed. Opportunity to express these behaviours should be considered part of species-appropriate animal husbandry, even though the opposite is the case in modern stables with total mixed rations.

Biodiversity – benefit and beneficiary

To conclude, grazing natural pastures is a means to promote animal welfare and health, inherently providing healthier products, better protein efficiency, and, depending on appropriate management, sustaining grasslands with their important ecosystem services. In well-managed systems, botanical biodiversity is beneficiary and benefit at the same time.

The *ceterum censeo* on this topic are methane emissions from ruminants, which cannot be neglected but should be much stricter contextualised and compared with the ecosystem services described above. Not least, methane-inhibiting potentials of herbal phytochemicals are broadly investigated. Generalisable in vivo proof is, however, lacking so far.

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References: **www.rural21.com**

World map of pastoralists

The world map of pastoralists, prepared for the 2026 International Year of Rangelands and Pastoralists, currently has information on over 800 groups of pastoralists worldwide.

A pastoralist group is a community that manages animals in a pastoralist system (one where the animals walk to their feed). They may be a particular ethnic group or caste, have a specific cultural identity and traditions, use a particular management system, raise specific species or breeds, or occupy a particular region.

The boundaries of pastoralism are fuzzy. But we exclude livestock farming (where animals are kept in fields or enclosures) and intensive livestock raising (where they are kept indoors).

Pastoralism is practised mainly where it is too hot, too dry, too wet, or too steep to grow crops. That means in and around the world's deserts and steppes (like in the Sahel), in mountains and on moorlands. Pastoralists also herd their animals on fallow crop fields, in forests, and on roadsides and patches of land between fields.

Pastoralism includes a wide range of management approaches. These, and the species kept, differ from one region to another. Many pastoralists are location-bound: they stay in one place all year, allowing their animals to feed on nearby pasture and fallow fields. In mountainous areas, they practise vertical transhumance: taking their livestock up the mountains in spring and down to the snow-free valleys in autumn. In drylands they use horizontal transhumance: moving between two or more fixed locations to follow the seasonal rainfall. Or they may be nomadic: moving frequently in search of grazing and water.

In parts of the Americas, Australia and southern Africa, ranchers keep large herds of cattle and sheep on land that is privately owned or leased from the government. In subhumid parts of Africa, South Asia and Europe, agropastoralists grow crops as well as herding livestock. Urban pastoralists use sheep and goats to control weeds and prevent fires in cities.

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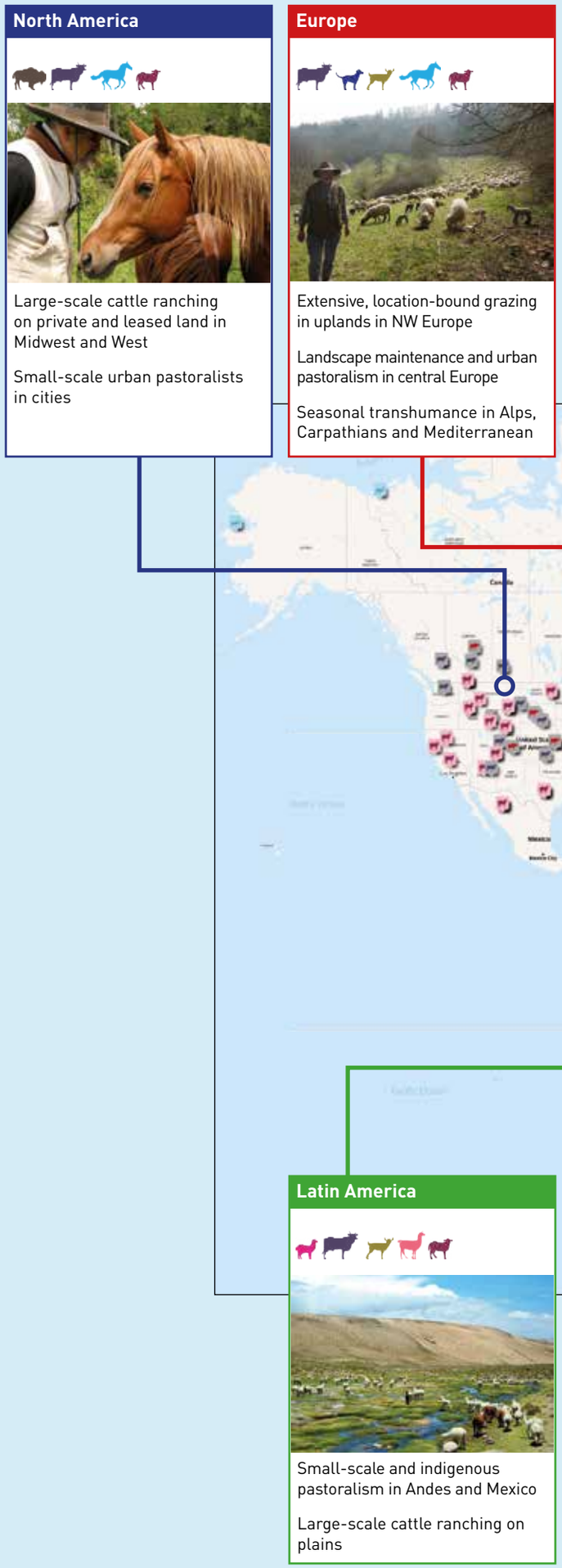
Pastoralist species and uses

- **Alpaca** — Meat, wool
- **Bactrian camel** — Meat, transport
- **Buffalo**
- **Bison** — Meat
- **Cattle** — Draught, dung, hides, meat, milk, transport
- **Dog** — Guarding, herding
- **Donkey** — Transport
- **Dromedary camel** — Meat, milk, transport
- **Duck** — Eggs, meat
- **Goat** — Landscapes, meat, milk
- **Horse** — Draught, herding, meat, transport
- **Llama** — Transport, wool
- **Pig** — Meat
- **Reindeer** — Draught, hides, meat, milk
- **Sheep** — Landscapes, meat, milk, wool
- **Yak** — Draught, meat, milk, transport

To see the full map with details of each group, visit www.pastoralpeoples.org/pastoralist-map/
The map is a work in progress.
Contact mapping@pastoralpeoples.org with corrections and additions.



Middle East and North Africa

Mobile herding in Iran, Iraq, eastern Turkey, the Levant, Yemen and North Africa

Recreational herds of dromedaries with paid employees in Gulf

Arctic

Extensive herding of reindeer following seasonal migration routes

Central Asia and Himalayas

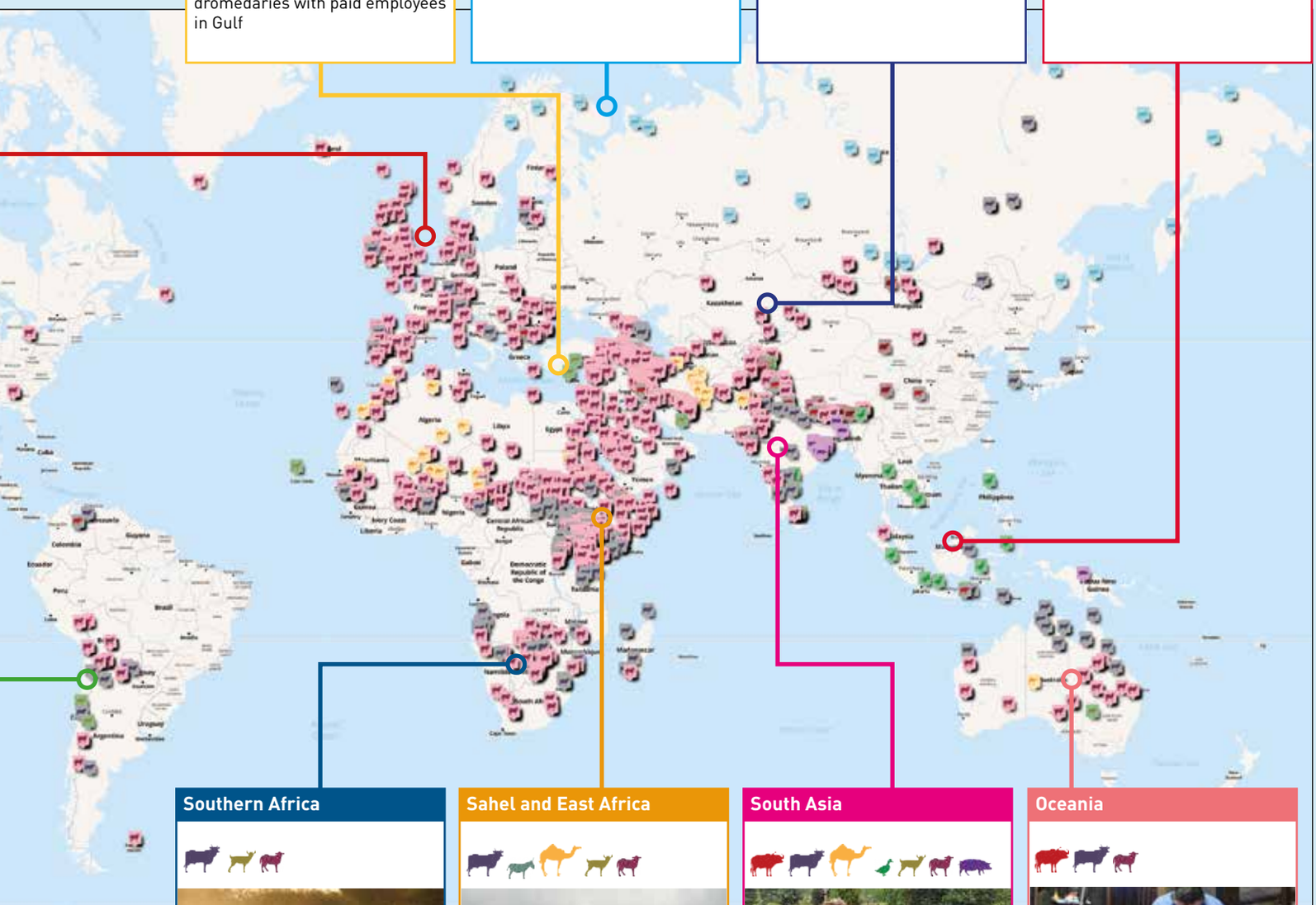
Horizontal transhumance in central Asian steppes

Vertical transhumance in mountains

Southeast Asia

Location-bound herding in plantations

Nomadic duck herding in ricefields



Southern Africa

Cattle ranching in South Africa and Botswana

Agropastoralism and location-bound herding elsewhere

Sahel and East Africa

Nomadic and seasonally transhumant herding

Trade with crop farmers for grain and household items

South Asia

Nomadic herding in deserts and on fallow fields

Location-bound herding and agropastoralism

Oceania

Large-scale ranching for meat and wool

Livestock insurance – promise of a resilience-building tool for pastoral communities

Against the background of climate change, insurance schemes are also becoming more and more important for livestock keepers. Together with partners in the public, private and non-profit sectors, the International Livestock Research Institute has developed an index-based insurance programme which protects livestock keepers in drought-prone arid and semi-arid lands from climate-related losses. Initial experience with the scheme appears to be promising.

By Rupsha R Banerjee and Kelvin Shikuku

Livestock plays a significant role in most rural livelihoods in the Global South, as it is a source of income and employment, as well as being a social security net for the poor, especially for women, and pastoral communities in general, while being a source of nourishment to both urban and rural population. However, livestock is also most vulnerable to climatic shocks and associated effects that come with it. This in turn adversely affects the communities depending on it for livelihoods, social protection, food, income among others, making households, communities and economies themselves extremely vulnerable, and pushing them into poverty traps and marginalisation. Livestock insurance can be an effective tool to help reduce such vulnerability of both women and men, households and enterprises, especially since more than one billion people dependent on livestock face multiple climate hazards. This becomes more critical as only a fraction of climate investment is allocated to the development of livestock-based systems.

If insurance products are centred around households, this attracts more women to take up the products.

Photo: Zerihun Sewunet/ ILRI

Two types of insurance schemes

Specifically for livestock, two types of insurance products exist: i) conventional indemnity-based insurance and ii) index-based insurance. Conventional indemnity insurance centres on actual loss and damage, with a farmer or livestock keeper being compensated for the loss of the animal because of disease, predator attack and/or theft. Such schemes are mainly applicable in mixed crop-livestock and/or dairy systems. Index-based insurance relates to weather or vegetation indicators and is particularly suitable for extensive systems such as pastoral areas which are home to nomadic and semi-sedentary livestock keepers and herders. Taking the specific example of index-based livestock insurance, such products have been specifically designed to protect pastoralists in the face of drought. The index in this case is the forage available, which, when it falls below a pre-defined threshold, triggers pay-outs which increase in proportion to the severity of estimated forage scarcity. This assumes that, when forage is scarce, grazing resources are depleted quickly, leading to deteriorating livestock conditions and increased livestock mortality. Thus, pastoralists could use the pay-outs to make production decisions that reduce their herd losses during the drought, including purchasing animal fodder, water or veterinary services. The index is derived by the Normalized Difference Vegetation Indices (NDVI) data.

Index insurance is advantageous for several reasons. Because pay-outs are not based on farm-level damages but on an objective index, transaction costs are reduced and moral hazard and adverse selection, which plague indemnity-based insurance, are minimised. Low administration costs can reduce insurance premiums, increasing affordability of the policy for smallholders and pastoralists. In addition, because insurance is based on reliable and independently verifiable information, re-insurance is relatively straightforward, and insurance companies can transfer part of the risk to international markets. Over the past years, the International Livestock Research Institute (ILRI) has developed such an insurance system together with partners. The index-based livestock insurance (IBLI) implementation model has had the private sector (insurance companies) at the forefront of offering the product to the clients (in this case the pastoralists), with ILRI's role being the research for development partners responding to the needs of both demand and supply. In addition, ILRI has acted as a broker getting different actors (academia, private, public, implementation and humanitarian, among others) together for better market and capacity development, adoption and scaling in the rangelands of East Africa.

Impacts at household and community level

In order to understand the impacts of index-based livestock insurance on the behavioural changes and welfare benefits at house-

hold and community level, a panel was set up in both Kenya and Ethiopia where household data were collected on various welfare indicators. It was found that during drought, households with IBLI coverage have higher incomes and milk production, are 27–36 per cent less likely to skip meals and 22–36 per cent less likely to sell livestock – a practice known as distress selling because this is a period when prices are lowest. Moreover, IBLI coverage increases investments in livestock as a productive asset. A study in Kenya found that over three years of IBLI coverage, average veterinary expenditures doubled, and livestock sales in non-drought years increased by an average 46 per cent. These and other changes to production strategies among the insured seem to pay off, increasing the milk productivity of livestock and the total value of milk produced. Positive impacts on other indicators of well-being were also observed, including greater household income per adult equivalent and improvements in mid-upper-arm circumference (MUAC), a strong predictor of child malnutrition. Even in the absence of severe drought or indemnity payments, IBLI was shown to improve purchasers' well-being by providing ease of mind. Furthermore, a study in Ethiopia indicated that women were purchasing insurance at higher rates than men, while a study in Kenya showed that women tended to have better access to credit if they were IBLI policy holders. Uptake of index insurance has also been found to improve education outcomes.

The evidence presented clearly demonstrates that products such IBLI play a critical role in coping with climatic shocks such as droughts. Adoption of the technology as a social safety net programme by the Government of Kenya and the World Food Programme in Ethiopia suggest that it can be an effective instrument in resilience-building. However, challenges remain on several fronts, which also provides opportunities for innovation, research and testing new business models for uptake and scaling. Some of these challenges encountered have been around low uptake, varied understanding of insurance products and high loss ratios by the insurance companies in the wake of massive payouts because of frequent and intense shocks, such as the recent prolonged droughts of 2021–2022 experienced in the Horn of Africa.

Some bottlenecks

In the rangelands, over time, pastoralists have used traditional ways of community insurance, such as helping their community with animals in the event of a loss, sharing resources amongst themselves when in need. However, when it comes to financial services such as livestock insurance, the communities want to see the immediate and tangible benefits of the same. Moreover, in the rangelands, the complexity and fragility of the contexts often lead to shifting priorities among individuals and the community, which in turn result in low uptake and use of insurance schemes. In such contexts, especially with the impacts of climate change being felt in multiple directions, insurance needs to be provided with other services to be viable and encourage uptake by livestock keepers. This also leads to the point of understanding how these schemes work, and to the recognition that they are neither a savings account or fixed deposits nor a lottery ticket. Often, while offering products such as livestock insurance in the rangelands, misinformation about the product and the purpose it is supposed to serve may lead to an initial surge in uptake, but quickly decline once the reality of what the product can and cannot do comes to light. In addition, complexity of insurance products, basis risk and the limited capacity of the suppliers to ensure last-mile delivery are some of the bottlenecks that prevent smallholder farmers and livestock herders from using the insurance products.

One issue which often goes unnoticed is around targeting and not paying attention to the fact that gender roles are critical in the pastoral areas. Right from the type of livestock ownership to access to resources and services, insurance is often treated in a binary fashion, i.e. assuming that men and women have similar needs and preferences for insurance. Typically, in the pastoral settings large livestock types like cattle and camels are owned by men and the small ruminants and poultry by the women. Recent work done by ILRI in collaboration with partners have shown that there is significant difference in income expenditure between men and women during shocks and normal periods and also access to markets depending on the type of livestock in question. In addition, studies are showing that if insurance products are centred around households, this attracts more women to take up the products; one example here has been reframing the livestock insurance to family insurance, showing that women were more responsive to purchasing the product.

The next steps

Any market-driven financial and non-financial service has to be gender responsive, socially inclusive and embedded within local, regional and/or national institutional mechanisms. Capacity development sits at the heart of uptake and scaling of insurance products as stronger delivery mechanisms also enable market development and private investment attraction. This requires innovations in delivering as well as offering these services based on need and demand in the pastoral communities, which in turn means investing in intensive market research, extension and education for demand-driven products and in offering complementary services, along with developing and understanding inputs and services markets in these fragile, complex and dynamic contexts.

Going forward, capacity enhancement and development together with advocacy for enabling environment for up-scaling and out-scaling of the risk management solutions such as livestock insurance continues to be at the heart of ILRI's agenda. This includes research questions on the relationship between livestock insurance products in conflict mitigation and peace-building in fragile systems and also the role that livestock insurance products like IBLI can play in strengthening graduation programmes through coupling asset building with asset protection. Anchored on the legacy of the index-based livestock insurance, ILRI will continue to work on risk management solutions which are not just limited to financial services but represent a comprehensive approach to de-risking, taking into account processes, practices and social differentiation for providing effective tools for strengthening systems and building resilience in the rangelands and the pastoral communities in the Global South.

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Unveiling opportunities and reducing climate vulnerability in the camelid value chain in the Andean Region

Camelids are vital to indigenous communities in over 90 countries, forming a crucial part of their economy and cultural identity. Despite this, their value and potential have been underestimated and lack adequate support and investment. In Andean countries like Bolivia and Peru, leaders in the breeding of alpacas and llamas are exploring new opportunities in key links of their value chains to address the effects of climate change.

By Ana Maria Vela, Maria Gracia Aguilar, Maruja Gallardo and Maria Reneé Pinto

The South American camelids consist of four species: *alpacas, llamas, vicuñas and guanacos*. The first two are domesticated species that sustain the economies of around 143,000 families in rural indigenous communities of Bolivia and Peru, providing milk, meat, skin, and textile fibre, as well as serving as a means of transportation and load bearing. Many families prioritise their breeding due to their adaptability to geographical and climatic conditions where other livestock species do not survive. Additionally, camelids stand out for their unique grazing method that does not harm the soil and prevents desertification, as they cut vegetation with their teeth and, shaped as they are, their hooves cause no damage.

However, the habitat of these two species has been facing climatic risks in recent decades, such as intense droughts caused by rising temperatures and reduced rainfall, as well as out-of-season frosts. Faced with this situation, women, who in most cases lead the breeding, are forced to take their livestock to higher altitudes in search of pasture and water sources, or to sell their animals anticipating imminent deaths because of climatic conditions and the inability to buy fodder or cultivate pastures due to lack of water. In territories 3,600 metres above sea level or higher, llama and alpacas' populations represent the main source of livelihood in fragile and vulnerable ecosystems.

In this context, the camelid value chain presents structural complexities that hinder the insertion of Andean highlands pastoralist families into the market under a sustainable and profitable approach. Alpaca ranching is oriented towards fibre production for textiles, and in the case of llamas, there is a growing insertion into the market for fresh and dried meat ("charque"). Their breeding faces challenges from genetic selection to ensure better fibre quality, as well as efficient management of pastures and water in high-altitude terrain, and infrastructure for livestock care. In the manufacturing process, most communities offer raw materials in fleece, carcass, or skin because families, in many cases, lack the categorisation and classification knowledge to add value and offer the fibre in one of the six differentiated qualities. At the commercialisation level, the chain still involves many intermediaries, which harms income.

Various national programmes in Bolivia and Peru, as well as international cooperation projects, focus their efforts on rural extension and industrialisation, which have improved basic conditions to some extent. This article describes experiences in both countries, implemented through the *Andes Resilientes al Cambio Climático* regional project, facilitated by the Helvetas Swiss Intercooperation-Avina Foundation consortium and financed by the Swiss Development Cooperation (SDC). The experiences stem from the need to identify links in the Andean camelid value chain with significant and sustainable impacts, considering present and future climate scenarios, the empowerment of women in the manufacturing process and the formulation of financial products that change the sector's perception towards this economic activity.

An underestimated potential: alpaca women, key to climate adaptation in Peru

Peru has the largest population of camelids in the world and is the leading producer of alpaca fibre, with 5,000 tons per year thanks to the breeding of over 4.5 million specimens. Alpaca fibre has gained ground in the international textile market thanks to its greater softness compared to other fibres. Sixty per cent of those employed by the sector are women, and they are involved in areas ranging from breeding to the classification and sale of fibre. Around 98 per cent of the produced fibre is

At roughly 4,000 metres above sea level, the camelid value chain is the sole viable productive activity upon which families rely for their subsistence in Peru.

Photo: Esteban Barrera

marketed through intermediaries without any primary value-added process, conditioning that breeders receive a lower market price. The fibre is produced primarily for export.

Before reaching markets and going through intermediaries, the alpaca fibre has to be categorised and classified, processes carried out in collection centres in high Andean territories, which allow increasing the selling price, improving negotiation conditions from alpaca breeders and breeders' organisations, and raising their incomes. Both activities are mainly carried out by rural women in their roles as Master Alpaca Fibre Categorizers and Classifiers. To enhance the technical skills of these women and promote their access to the labour market, the Ministry of Agricultural Development and Irrigation (MIDAGRI) developed two initiatives in 2022: training courses for Master Categorizers and Classifiers, and the certification of their labour competencies by the Ministry of Labour and Employment Promotion (MTPE) according to Peruvian technical standards.

The training and certification of the Masters allow them to be hired by public and private entities to provide their technical services in collection, categorisation and classification, ensuring quality for the commercialisation of fibres. Training is conducted by senior Masters to junior apprentices, being a model of local training that works well in rural areas. In addition to technical content, the courses include business management and a practical session focused on sustainable alpaca breeding, with visits to successful experiences in climate change adaptation, such as greenhouses for pasture and water management strategies. These actions are framed to promote improvements in the living conditions of the Master Categorizers and Classifiers and alpaca grazing families in the current context of climate change, which include business strategies aligned with the adaptation measures of the agricultural sector of Peru's Nationally Determined Contribution.

Rural women who classify and categorise alpaca fibre are the links in the value chain that ensure better income for breeding families and serve as ambassadors for climate adaptive breeding practices.

Photo: David Mendoza

Boosting new perspectives on access to financing in the camelid value chain in Bolivia

South American camelids are among the main livelihoods of peasant communities in Bolivia, with around 2.5 million llamas and alpacas. About 30 per cent of the income of 53 thousand households in the Andean Highlands is generated by these animals, with limited transformation into textiles, crafts and processed meat. The sector in Bolivia had over 20 years of government support, leading to a growth in the llama meat market from 4.1 million US dollars (USD) in 2004 to 32 million USD in 2022. Despite this, issues such as low productivity and yield, as well as climate impacts resulting in limited availability of pasture and water, do not allow for the consolidation of small and medium producers (SMPs) in territories where it is the only possible productive value chain with market insertion.

In this context, since 2016, the Pro-Camelids Programme of the Ministry of Rural Development and Lands (MDRyT) has identified the need to consider climate change and associated risks in financial products aimed at SMPs in the camelid sector. Currently, these products do not consider climate risks, which hinders access to credit for SMPs, who bear the cost of possible adverse impacts. To address these demands, the integration of identified climate impacts in existing financial products offered by banking has been proposed in a study supported by the *Andes Resilientes* project.

Limited pasture and water availability hinder small and medium producers from consolidating their positions due to low productivity.

Photo: Mauricio Zaballa Romero

The proposal is to establish an institutional and normative framework to channel resources that strengthen adaptive capacity to climate change in the camelid sector. The objective is to create the *Climate Trust Fund for Camelids*, which mobilises resources from international funds and the national public budget to finance products such as credits, guarantees, insurance and climate assessments, as well as investments in national market titles to ensure their sustainability. Revenues recovered from the loan portfolio will be reinvested in new loans and fund improvements.

To ensure the effectiveness of these financial products on the ground, the proposal includes a diagnosis that identifies best practices that contribute to climate change adaptation according to each ecosystem where camelids are bred. These practices include, for example, water wells, fences for corrals and drought-resistant pasture seeds as "hard" practices related to infrastructure and technologies, and training, pasture rotation and identification of animals more resistant to drought as "soft" practices referring to changes in capacities and

skills. The potential adoption of this new perspective for the financial sector is based on the establishment of clear guidelines for evaluating credit and insurance applications for good climate practices that can help the camelid sector be sustainable and profitable.

Reducing vulnerabilities, intervening where intervention is not common

Both experiences show that camelid value chains are highly vulnerable to climate change, with impacts already showing. Based on the climate scenarios of the IPCC "Shared Socioeconomic Pathways" (SSP) 7.0 and 8.5 (see Box), an increase in temperatures and anomalies in precipitation is expected for the period 2081–2099, leading to up to a 20 per cent water deficit in the central and southern Andean highlands. This raises concerns about water stress events and extreme droughts of up to six months.

The interventions supported by the *Andes Resilientes* project focus particularly on value chain's links that have historically required strengthening but that can also make significant contributions to reducing climate change impacts. Training, financing and market access are crucial to ensure an understanding of climate risks in camelid breeding and production and to define measures that allow more effective adaptation. For example, there is a reduction in vulnerability with the training of women Master Categorizers and Classifiers in Peru by including techniques for alpaca breeding resistant to climate variability. This, in turn, increases alpaca fibre production allowing for better income. The 63 women trained by the project managed to increase their contribution to the national production in collection, classification, and categorisation from 3 per cent to 5.13 per cent in two years, which resulted in sales of 7.8 million Peruvian soles (around 2.10 million USD). In Bolivia, the implementation of financial products, such as credits and agricultural insurance, that consider the risks of climate change can increase the adaptive capacity that breeding families face. Specifically, insurance can affordably cover damages and losses derived from climate events and ensure the improvement of the quality of life of communities and the maintenance of ancestral knowledge in camelid breeding.

Shared Socioeconomic Pathways (SSPs)

In its Sixth Assessment Report (AR6), the Intergovernmental Panel on Climate Change (IPCC) introduced new climate change research scenarios called Shared Socio-Economic Pathways (SSPs). SSPs are standard greenhouse gas concentration scenarios used in mathematical models that simulate what the global climate would be like, including physical processes occurring in the atmosphere and ocean, as a response to the increase of greenhouse gas emissions. Five core SPP scenarios (SSP1 to SSP5) have been developed, each representing different future trajectories for greenhouse gas concentrations based on varying assumptions about factors like economic growth and inequality. Both SSP 7.0 and 8.5 are high-emission scenarios that fall under the pathway of SSP5 after certain conversions.

In summary...

The camelid sector already has enormous gaps, accentuated by the effects of climate change in the highland Andean ecosystems. Therefore, any strategy led by states, local governments or international cooperation must have comprehensive interventions that strengthen key links throughout the value chain, such as training, financing and market access, considering the projected impacts of climate change.

The shared experiences show strategies for the climate adaptation of camelid value chains, reducing vulnerability and increasing the adaptive capacity of their breeders. In Peru, the comprehensive strategy of training rural women as Master Alpaca Fibre Categorizers and Classifiers drives rural extension and job placement, and improves fibre quality, increasing incomes for alpaca breeder families, and at the same time, promoting adaptive best practices, from a spokesperson role. In Bolivia, the Climate Trust Fund for Camelids is a solid first step to influence the incorporation of climate risk for the sustainability of the livestock sector in the Andean highlands. The next steps include discussions between the Ministry of Rural Development and Lands and financial entities to develop and implement the mechanism with the inclusion of climate risks.

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Facing climatic risks like droughts and frosts, it is crucial to shift the financing sector's perception to recognise the challenges camelid breeders encounter, ensuring their access to financial support. Llamas in the Andean highlands of Bolivia.

Photo: Mauricio Zaballa Romero

Unleashing the potential of women livestock keepers

Livestock keeping and production can make a significant contribution to Sustainable Development Goal 5 in achieving gender equality and empowering women. But to enable women to meaningfully operate in, and benefit from, the livestock sector, numerous obstacles and constraints have to be cleared. Here, taking the example of India, our author presents some promising approaches.

By Mahesh Chander

According to the UN Food and Agriculture Organization (FAO), women comprise about 43 per cent of the agricultural labour force in developing countries where they are engaged in crop production, animal husbandry and food processing. It has been estimated that rural women represent two thirds of low-income livestock keepers world-wide; particularly in the small-scale livestock sector, they are heavily engaged in developing countries. In many regions including India, women are primarily responsible for the daily management of livestock, including feeding, milking, cleaning and healthcare of animals. Their involvement in livestock farming helps alleviate poverty by diversifying income sources and providing a buffer against economic shocks. The additional income generated from livestock farming allows families to invest more in education and healthcare, improving overall well-being.

In many regions, women are primarily responsible for the daily management of livestock, including feeding, milking, cleaning and healthcare.

A whole range of challenges

However, women livestock keepers face a multitude of economic, social and institutional obstacles. They often have less access to essential resources such as land, credit, technology, veterinary services and training compared to men. Also, they frequently have limited decision-making power within households and communities, affecting their ability to influence livestock-related decisions. In many developing countries, cultural and legal barriers prevent women from owning land, which is a significant constraint since land is a crucial asset for livestock farming. Even if a woman owns the land, it is often controlled by her husband or father. Moreover, without land, women lack collateral for loans and access to regular financial services, limiting their ability to expand their livestock operations and potential to enhance productivity. In India, smaller livestock like goats and poultry in backyards are mostly owned by women from weaker sections of the society, but given the opportunity of credit they would expand into other livestock species, including dairy animals like cows and buffaloes. Also, women often face difficulties accessing markets to sell their livestock products, which can be due to lack of transportation, market information, or social restrictions. Agricultural extension services providing training and resources mostly target men, thereby excluding women from critical learning opportunities and hindering their ability to adopt improved practices and technologies. The formal participation of women in agricultural institutions and associations including cooperatives is far lower than that of men, making them "invisible workers". Moreover, women frequently perform multiple roles, such as household responsibilities and childcare, which can limit the time and energy they can dedicate to livestock farming.

How to improve the situation for women?

Women need literacy (including digital & financial), education and gender awareness to tackle taboos and archaic gender norms hindering their empowerment. Enhancing their access to land, credit, inputs, veterinary and extension services and markets is critical for boosting their productivity and economic contribution. Community-based approaches, such as women's cooperatives, self-help groups or Farmer Producer Organisations (FPOs) can be effective in providing them with support networks, resources, and collective bargaining power.

Digital tools such as mobile apps, SMS messaging and social media can help reach women farmers in remote and rural areas, allowing them to save time and labour, adapt to climate change, participate in decision-making, access extension services and create new entrepreneurship opportunities. Here, initiatives like women-led information networks designed to connect women farmers and agricultural experts can provide women access to information on sustainable agriculture practices, market opportunities and financial management.

Similarly, digital agro-innovation hubs focused on promoting the use of digital technologies can offer training and mentorship programmes for women farmers using mobile apps for livestock management to access online marketplaces, digital tools such as weather apps, livestock management software and e-learning resources. Technical information obtained via mobile phones like data on balance feeding, good husbandry practices and animal health and reproductive care translates into higher productivity, reduced veterinary expenses and lower animal mortality. Women, especially those coming from weaker sections of society, may experience difficulties accessing and using these tools, but the extension agents and service providers can assist them. Women are often inclined towards digital tools and are flexible in adapting to change with substantial support but have limited access to smartphones, tablets and the Internet. Their low literacy rate, lack of skills in Information and Communication Technology (ICT), and other factors hinder them in using practically all ICT tools.

In India, smaller livestock like goats in backyards are mostly owned by women from weaker sections of society.
Photos: Mahesh Chander

Extension and advisory services must have a good number of female staff who can have regular engagement of household members enabling behaviour change and an increased understanding of the significance of women's participation in livestock activities. This will also encourage household members to be more supportive of women farmers attending training programmes and discussion groups, leading to an increase in women's participation in such events and activities, and their access to technical and institutional knowledge and markets. Greater participation in personal, household and farm-related activities will result in the economic, social, and psychological empowerment of women farmers, with a long-term positive impact on livestock production.

Government support for women's empowerment

Microfinance programmes targeting women can help them invest in livestock, improve productivity and enhance their economic status. In India, various state governments have announced schemes to offer women soft loans. For instance, a scheme for providing support to women entrepreneurs was announced on International Women's Day in 2022 by Haryana State. Under the scheme, women whose family annual income is less than 0.5 million rupees (5,590 euros) are provided access to soft loans of up to 0.3 million rupees by financial institutions. Subsequently, the interest subvention of 7 per cent is also provided for three years through the Haryana Women Development Corporation. The public sector banks in India have schemes to support women self-help groups (WSHGs). The National Bank for Agriculture & Rural Development (NABARD) implements and support the Women SHG scheme announced by the Government of India in backward and Left Wing extremism-affected districts through NGOs, which play a key role in promotion and credit linkage of WSHGs with banks.

A Gender Budget Cell has been set up in the Government of India's Department of Animal Husbandry & Dairying (DAHD). This cell is mandated to shape the DAHD's policies and programmes in a way that could tackle gender imbalances, promote gender equality and development of women. The DAHD advises states and implementing agencies to utilise 30 per cent of allocated funds towards women under the schemes it funds. Also, one of the goals of the Indian National Livestock Policy (NLP) of 2013 happens to be women's empowerment.

Fostering cooperative power and entrepreneurship

India's National Dairy Development Board (NDDB) promotes women dairy cooperatives. Under the National Dairy Plan Phase 1 (2012–2019), participation of women in the dairy sector was formalised, with Milk Unions being encouraged to organise all-women dairy cooperatives. Various initiatives like appointment of Lady Extension Officers (LEOs) and the establishment of more than 4,000 all-women cooperative societies during the project period put a strong focus on women's involvement in the dairy sector. The NDDB also encouraged and trained women producer members from across the country, which has enhanced the awareness level of women milk producers and helped them become active contributors in the entire dairy business ecosystem. As the nodal agency to utilise the services of women members of SHGs/ Training and Capacity Building of Human Resources, the NDDB has so far trained 61 Multi-Purpose Artificial Insemination Technicians as livestock resource persons and primary service providers through a new accredited model, 'A-HELP' (Accredited Agent for Health and Extension of Livestock Production). The NDDB also initiated the Women's Dairy Cooperative Leadership Programme (WDCLP) to strengthen cooperative movement by significantly increasing the participation of women as active members and as leaders in governance of cooperative societies, unions and federations. The Board provided assistance to dairy cooperatives in organising women clubs, women literacy programmes, thrift and credit groups, training programmes, also on District Cooperative Societies (DCS) activities, and exposure visits, as well as training programmes in member responsibilities

and rights, and Management Committee Members' duties and tasks. The Leadership Programme helped raise women's awareness about their rights and responsibilities as co-operative members and encouraged their involvement in social and economic activities. The NDDB continues to organise seminars, conferences and training programmes to assist women in developing leadership qualities and augment their participation and overall representation in the cooperative system of dairying.

All Women Dairy Cooperative Societies could to some extent overcome the problem of women's limited leadership opportunities and participation in decision-making. The success of women in dairying needs to be replicated in other livestock species like goats, pigs and poultry, e.g. by organising women into self-help groups, women-producer organisations and cooperatives, thus improving their contribution in policy-making processes as well as their bargaining power and access to inputs and markets. One good example is the National Smallholder Poultry Development Trust (NSPDT), facilitated by the NGO Pradan, which enables poor women in rural India to start and run successful poultry enterprises. Similarly, The Goat Trust as one of the largest organisations working in promoting goat-based livelihoods and establishing highly specialised goat-based value chains, has empowered a significant number of women through goat husbandry. The Swablambi Mahila Bakari Palak Farmer Producer Company (FPO), promoted by The Goat Trust in Barabanki district of Uttar Pradesh, is truly a women-led FPO for goat rearing since all its members, including the Board of Directors, are women. This FPO has set an excellent example for the other women-led goat-based FPOs to follow.

The *Pashu Sakhi* scheme has become very popular in India, particularly in small-scale goat production by women, being implemented by several NGOs and government departments to create awareness and capacity building of the community on livestock-based livelihoods activities and facilitates aggregation and marketing of the livestock products. A *Pashu Sakhi* (Woman animal friend or Woman livestock counselor/paravet) is a Community Animal Care Service Provider (CASP) that enables last-mile coverage in rural areas where clinical services for livestock are not available on time or expensive to afford for rural poor. *Pashu Sakhis* also support the members of the producer groups in animal rearing and management towards empowerment of women. They are trained through structured training programmes by the livestock experts and act as medium of interface between the Animal Husbandry & Veterinary Department and rural poor by linking the households to the nearest veterinary aid centre at the time of need.

When a woman…

- *ventures out of home and talks to an extension agent regarding livestock development schemes, credit opportunities*
- *calls a veterinarian to seek advice on her livestock's health issues over a phone*
- *calls livestock traders to negotiate purchase or sale of livestock*
- *joins a self-help group to raise livestock and buy livestock inputs collectively*
- *gets engaged in processing and marketing of livestock products individually or collectively*

…it's empowerment.

The NGO Aga Khan Rural Support Programme (AKRSP-India) has organised women into Goat Rearing Groups (GRGs) to create a platform for extension of best practices and collective action, and has so far reached more than 55,000 goat rearing households. It has also created a cadre of women extension workers to provide preventive health services for goats. The services include deworming, vaccinations and knowledge extension. *Pashu Sakhis* charge for their services from the goat rearers to ensure the viability of their services. So far, over 1,200 village level paravets have been trained under this programme. Members of women self-help groups in Madhya Pradesh promoted by the Programme have also taken up poultry as an income-generating activity for women, making an impact by improving existing backyard poultry and promoting commercial poultry as a micro-enterprise among tribal households.

Summing up

Implementing gender-sensitive agricultural policies and programmes that recognise and support women's roles in agriculture is essential for maximising their economic impact. Rural women need focused training initiatives to cultivate an entrepreneurial mindset among them, inspiring them to come forward, join hands to develop business plans and identify the necessary resources. Initially, some, if not all of them, may switch from subsistence to commercial scale establishing individual or collective enterprises in due course, given their access to all the required resources to set up their enterprise. Over time, such initiatives will create a critical trained mass of women diversifying their income streams, generating an additional or alternative source of income for their families. It is likely that additional income would be invested by women for improving their food consumption patterns and dietary choices, leading to a positive impact on food and nutrition security.

Overall, while women in the small-scale livestock sector in developing countries face significant challenges, their contributions are vital for sustainable agricultural development and food security. Efforts to support and empower these women can lead to broader socio-economic benefits and more resilient agricultural systems. Addressing the challenges they face through targeted interventions and supportive policies can significantly enhance their impact on both household and community levels. Several NGOs, international organisations and governments are implementing programmes aimed at empowering women in the livestock sector by improving their access to resources, training and markets. Some countries are making policy changes to support women's participation in agriculture, such as land reforms and gender-sensitive agricultural policies. Livestock keeping and production can make a significant contribution to SDG 5 in achieving gender equality and empowering women. But to enable women to meaningfully operate in, and benefit from, the livestock sector, policies and programmes should work to remove all obstacles and constraints.

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References: **www.rural21.com**

Strengthening Uganda's beef industry through innovation

Satisfying the increasing consumer demand for food and animal proteins while minimising adverse environmental and social effects poses a significant challenge. So it is crucial to identify production methods that are both economically viable and ecologically sustainable. Recognising this need, the European Union (EU) has pinpointed the Ugandan beef industry as a key sector for sustainable transformation. The technologies suited to achieve this transformation were identified in the SIRGE project.

By Leonardo Frisani

Globally, the demand of meat and dairy products is expected to grow by more than 60 per cent, with the figure increasing in sub-Saharan countries to 70 per cent – driven by rising incomes and changing dietary preferences. In Uganda, the beef industry is an important contributor to the national food system (see upper Box). However, if action is not taken, the sector will also significantly contribute to greenhouse gas (GHG) emissions levels and this would make it difficult for Uganda to meet its Nationally Determined Contribution commitments for reducing emissions agreed upon with the international community.

Supporting transformation with the SIRGE project

To address the challenges, the EU Delegation to Uganda funded the charity Acted and its partner AgriTechTalk Africa (ATTA) to implement SIRGE (see lower Box). The project's objective was to foster innovation and access of rural communities and institutions to new technologies for rural transformation through the reduction of greenhouse gas (GHG) emissions and environmental impacts in Uganda's beef industry, which was to be attained through three main results: 1) enhancing innovation in livestock agriculture, focusing on food and nutrition security; 2) reinforcing the national and regional agricultural research architecture and innovation capacities and promoting multi-stakeholder partnerships for enhanced and long-term impact; and 3) increasing knowledge and evidence-based livestock management practices in adapting to and mitigating climate change in order to feed development policies and investment decisions.

The target areas of implementation were the districts of Nakasongola, in the Central Region of Uganda, and Mbarara, in its Western Region which are part of two of the three main cattle-corridor regions in the country, the other being the Karamoja sub-region.

A technician of the service provider Punta 360 discusses the data collected by the drone with an Acted field staff.

Photo: Ines Dadda for Acted

Calculating methane emissions

First, the consortium partners collected data on livestock body condition in the defined project boundaries and analysed and reviewed current livestock practices such as free range, feedlot and paddock systems. ATTA interviewed a total of 611 farmers (47 women, 564 men) on their livestock management practices (both dairy and beef). The extrapolated data was used to calculate and measure emission factors and emissions from the different project agroecological zones.

These activities were complemented by historic methane emissions calculations from satellite data to select sites for more accurate methane emission analysis using drones. A study was undertaken to research weather conditions and their effects on the GHG emissions in Uganda. Based on the results of a desk review, suitable locations with significant levels of methane emissions were selected for high-resolution *in situ* surveys from drones. The exercise concluded, as expected, that there was a high spatial methane concentration in areas with livestock farms. Moreover, in areas with lower temperatures and higher humidity, increased methane concentration was observed, while it was lower in areas with higher temperature and reduced humidity. Methane concentration was also higher in sections of the farms where free grazing is done more frequently and in areas with inferior rates of animal manure management. The findings helped to develop an online portal gathering all the produced maps to visualise the result of the data collections.

Setting up a livestock database

In order to analyse the role of grassland/rangeland management on carbon sequestration, in addition to the assessment of pasture management systems during field visits to the farmers, carbon pools below and above the ground were examined. Based on this, appropriate

energy coefficients of the various pasture management and grazing practices by animal categories were generated. Project partners also used internal tools of their own creation to collect data on livestock breeds, age, sex, feeding practices and purposes from the above-mentioned farmers (half each in Nakasongola and Mbarara). The findings were used to develop a livestock database with data on livestock characterisation and manure management. The database is a long-term deliverable of the project which will be used to calculate emission factors for each livestock category. To support the utilisation of the database, the project backed the participation of the government, through the Ministry of Water and Environment, in regional and international dialogues on the implementation of livestock coordination frameworks. For instance, at the end of 2021, Acted assisted staff from the Ministry's Climate Change Department (MWE-CCD) in participating in a bench-marking tour in Nairobi, Kenya, to improve monitoring and reporting on GHG emissions including short-lived climate pollutants (SLCP) and air quality management in Uganda. Following the tour, MWE-CCD developed a partnership with the Climate and Clean Air Coalition (CCAC) of the United Nations Environment Programme (UNEP) to collaborate for reducing SLCPs to protect human health, agriculture and the environment

Identification of mitigation measures

Based on analyses and data evaluations, the following mitigation measures to reduce GHG emissions of the livestock sector were identified: establishing proper manure management systems such as biogas production, utilising improved, highly nutritious pasture with increased yield potential, and keeping improved livestock breeds. For this purpose, the use of low-GHG emitting pastures (Napier grass and *Chloris Gayana*), the breeding of improved cattle species (Boran, Brahman, Tyrolean grey) and the adoption of agro-forestry and manure management practices was recommended to be supported. The analysis of livestock administration and management at the local and national level resulted in the recommendation of establishing a centralised livestock regulatory framework, the promotion of public-private partnerships and the merging of some governmental agencies whose roles overlap in livestock management.

Fostering the adoption of climate-smart livestock management practices

A range of activities were implemented to increase the adoption of evidence-based livestock management practices to adapt to and mitigate climate change. First of all, indigenous livestock crossbreeding with exotic breeds was promoted to foster a high production and productivity potential. For this purpose, a participatory and exploratory survey among cattle breeders was carried out to obtain data on the available breeds, breeding practices, purpose of each breed and management practices of the available breeds. Subsequently, incentive packages to adopt low emissions intensity breeds were explored. A total of 2,000 semen straws for Brahman, Boran and Tyrolean breeds were distributed to farmers in the districts of Mbarara and Nakasongola at 50 per cent discount. Moreover, qualified artificial insemination technicians in the two districts were identified and trained to assist the farmers in the insemination process and along the cattle's gestation period.

Advocating for the adoption of the livestock identification and traceability systems guidelines and model policy framework developed by the Intergovernmental Authority on Development (IGAD) was a further measure. Factsheets on proven GHG mitigation technologies and characterised dietary strategies in different beef production systems were developed and disseminated. The project also conducted in vitro trials to determine the GHG emission potential of different pasture/forage ecotypes in GHG emission chambers. Furthermore, in order to favour the adoption of suggested practices, the consortium partners built capacity and carried out awareness-building sessions on the impacts of GHG livestock emissions amongst policy-makers and key sector players.

By the end of the implementation period, three important project goals had been achieved. A database of Ugandan livestock cattle breeds and livestock-related practices had been established, a tool for the forecasting of livestock-related GHG emissions has been created and put at the disposal of the government, and climate-smart livestock practices helping adapt to and mitigate the effects of climate change had been identified. Acted and its partners now aim to build on these results and make a lasting difference in the Ugandan livestock sector towards productivity and environmental sustainability. This requires implementing the identified practices on a larger scale across the above-mentioned cattle-corridor regions and beyond. Recently, the government supported the International Fund for Agricultural Development (IFAD), which submitted an application to the Green Climate Fund to receive funding for a similar project. Acted is looking for funds to finance a second phase of the project, which will be centred more on implementation than research.

Uganda's livestock sector

According to Uganda's 2021 National Livestock Census, the livestock sector contributes 4 per cent to the country's GDP. In all, there are 2.3 million cattle-keeping households, 34.1 per cent of which are female-headed. The total cattle population amounts to 14.5 million – an increase of nearly 27 per cent compared to 2008. Total milk production is at 71.7 million litres per week. Currently, 77 per cent of Ugandan cattle (11.2 million heads) are indigenous breed while 23 per cent are exotic/cross breed.

The project and its partners

The European Union identified the Ugandan beef industry as a priority value chain that can contribute towards food security and enhance economic development and employment for the country. The project SIRGE – Strengthen an innovative system for the reduction of greenhouse gas emissions and environmental impacts of the nascent beef industry in Uganda in support to rural sustainable transformation – has been implemented by the NGOs Acted and AgriTechTalk Africa in partnership with the Climate Change Department of the Ministry of Water and Environment and the Ministry of Agriculture, Animal Industry and Fisheries, and local implementing partners. The international NGO Acted has been present in Uganda since 2007 and works to address humanitarian, development and environmental issues in the country. ATTA is a Ugandan-registered international NGO that started operations in 2015 and has considerable experience in the field of livestock, crop and food security assessments.

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References: **www.rural21.com**

Narratives in the media often support a simplistic notion of farmer-herder conflicts. Photo: Stevie Mann/ ILRI

Farmer-herder conflicts in Africa – dynamics and potential solutions

Farmer-herder conflicts in Africa are receiving increased attention together with concerns over increasing and intensifying tension between the two groups. However, the question arises whether such concerns are really justified. A review of the literature suggests that there is indeed sparse robust evidence of such claims. This article presents the results of a systematic scoping literature review from the last two decades on that topic and develops a framework with concrete recommendations for future research.

By Fiona Flintan, Hussein M. Sulieman, Bedasa Eba and Magda Nassef

Conflicts between farmers and herders are increasingly coming under the spotlight. For example, in 2018, the African Union Commissioner for Peace and Security Smail Chergui stated that "conflicts between herders and farmers on the continent take more lives than terrorism", while a 2021 news article in *The Guardian* describes "violence linked to conflicts between farmers and herders across West and Central Africa has led to more than 15,000 deaths … half of those have occurred since 2018, most of them in Nigeria, which has created the country's deadliest security crisis."

Public domain literature often presents the topic with inflammatory language and labelling of particular groups. The Fulani, the largest pastoralist group in West Africa, are referred to as "strangers" or "aliens", or as a public danger. Often, this group is conflated with known terrorist organisations. The Global Terrorism Index for 2015 claims that Nigeria is home to "two of the five most deadly terrorist groups in 2014; Boko Haram and Fulani militants", using a catch-all term to describe the Fulani. Additionally, conflict incidents are presented inconsistently, with what is often a cacophony of causes and the farmers referred to as the victims and herders, with their pastoral, mobile way of life, as the assailants. Descriptions of the conflicts can be selective and tailored to particular actions or interventions, such as passing grazing bans to reign in pastoralists' "indiscriminate grazing", using degradation narratives to "legitimise and pave the way for agricultural investments and environmental conservation", using scarcity narratives to justify decisions taken to better manage "underutilised" resources, securitising and politicising climate change by linking climate change-driven migration with violence and insecurity and, perhaps most dangerously, extremist groups and politicians using and manipulating farmer-herder grievances to further their own territorial or political objectives.

Digging to identify the root causes

From 2022, the International Livestock Research Institute (ILRI), through the Supporting Pastoralism and Agriculture in Recurrent and Protracted Crises (SPARC) project funded by the UK Foreign Commonwealth and Development Office and the CGIAR Initiatives on Fragility, Conflict and Migration, and Livestock and Climate, have been digging deeper into these issues.

As a first step, and in order to better understand what research is saying about farmer-herder conflicts, a systematic scoping literature review was undertaken. The review explored academic and think-tank literature on the root causes of farmer-herder conflicts to uncover any trends and potential gaps in our current understanding. The review was first conducted in English and then in French to ensure the inclusion of as many studies as possible, and the results were combined.

Overall trends in published research

The search in *Science Direct* showed a marked increase in journal articles produced between 2000 and 2021, with around 10 produced in 2000 and more than 70 produced per year

between 2019 and 2022. This confirms the general consensus that interest in farmer-herder conflicts has grown significantly over the last two decades. Ninety-eight per cent of reviewed studies report that farmer-herder conflict is increasing in frequency, intensity, or both. However, most studies mention this as a general statement, and few show it as a research finding. All identified studies concentrate on West Africa and the East Horn of Africa, with the majority focused on West Africa, particularly Burkina Faso, Nigeria and Mali.

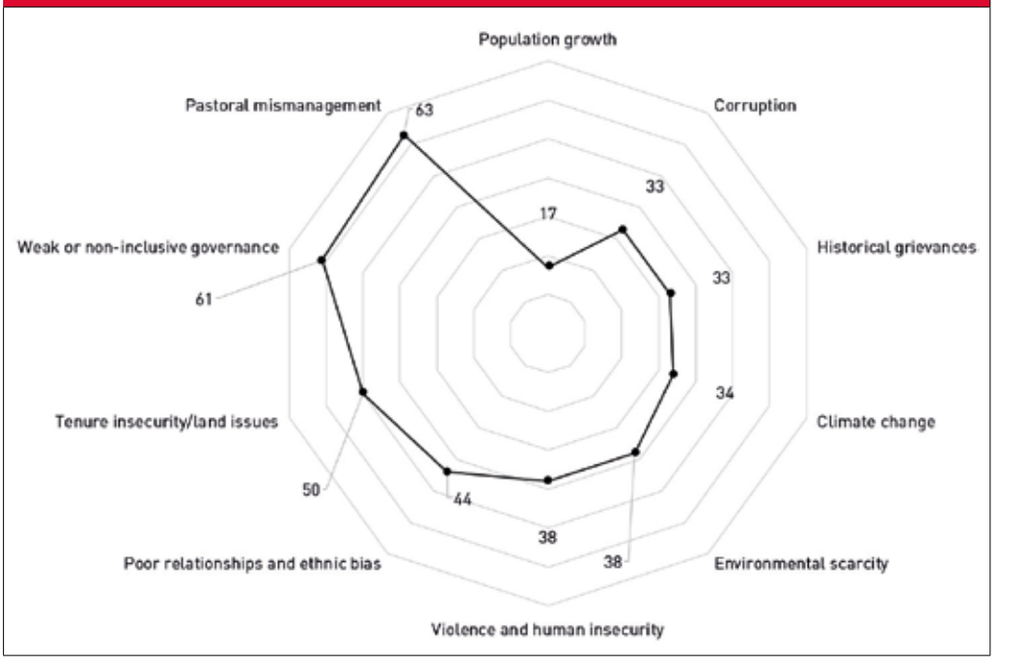
Neglect of the gender dimension of conflict has been acknowledged for some time, but still, nearly 20 years later, the role of women in conflict is not sufficiently discussed, particularly women's roles in promoting conflict or promoting peace. In this review, only 25 of the 88 articles and papers mentioned women in relation to the conflicts described. This suggests a continued gap in research.

Thirty-eight of the 88 publications mention youth, with 81 per cent of the articles/reports describing them as contributors to conflict, 50 per cent as victims and only 18 per cent as peacemakers. Although the studies did not emphasise the aspect, they explicitly referred to young men as being susceptible to recruitment into armed groups, forming vigilante groups for community protection, or tracking and returning stolen livestock, suggesting that the focus was on them and not on young women. No article included any specific description of youth indicating that they were talking about women or girls, pointing to a continued gap in the research. Additionally, we found no standalone research on the role of youth in conflict, indicating an area for further research.

While all studies reported land and natural resources conflict, most mention the link as a general statement like conflict or competition over land or water, a combination of the two. A handful of studies provided a deeper analysis. "Climate change" or "changing climate" was mentioned in 62 of the 88 papers (70 %).

All articles and papers identified multiple causes of farmer-herder conflict, with no paper citing a single cause. The most frequently cited cause categories were pastoral mismanagement, weak or non-inclusive governance, tenure insecurity, land issues, deteriorating relationships and ethnic bias. These were followed by environmental scarcity and violence (see Figure). Climate change, while a topic of general interest, did not feature in the top causes. While it is difficult to draw any definitive conclusions from these results, they do suggest that the causes most mentioned focus on governance, political and social factors of conflict rather than the more technical aspects of resource scarcity or climate change. This finding aligns with those from previous reviews. Additionally, the large number of articles that cite pastoral mismanagement as a cause of conflict (63 in all) suggest a simplistic reading of the conflicts that have deeper root causes found elsewhere, as well as likely influence of predominant narratives in the media.

Causes of conflict by category and frequency of mention



Conclusions and recommendations

While there has been a significant increase in attention given to farmer-herder conflicts over the last two decades, this review identified only a few primary studies. Though studies indicate increasing (or increasingly violent) tension between the two groups, most mention this as a general statement, and few provide robust evidence. This supports those researchers who refute the mantra of increasing conflict and call for more primary research and critical analysis. The review highlights the complex and multi-faceted nature of farmer-herder conflicts that cannot be simplified as one cause or another. Preliminary research from a Sudan local case study on farmer-herder conflicts in Gadarif State (see box on page 34) suggest similar conclusions.

The intricate web of causes suggests that researchers would benefit from a comprehensive framework in which to situate their research and better understand the underlying drivers of specific farmer-herder conflicts. The core elements of this framework are:

1. **Interconnectedness of causes:** Farmer-herder conflicts are rarely driven by a single cause, but rather by a combination of factors that interact with each other at different levels. These causes range from governance issues to environmental changes, historical grievances and cultural biases. A well-structured framework would help researchers map these interconnected causes and visualise how they influence each other, aiding in identifying root causes and potential leverage points for conflict prevention and resolution.
2. **Contextual understanding:** Causes and their effects vary based on geographical, social, political, and cultural contexts. A robust framework would allow researchers to incorporate these contextual variables and develop a nuanced understanding of conflicts that goes beyond generalised narratives.
3. **Avoiding oversimplification:** Oversimplification causes, such as attributing conflicts solely to environmental scarcity or climate change, can hinder accurate analysis and effective solutions. A well-structured framework would discourage such oversimplification and encourage researchers to delve deeper into the underlying structural drivers of conflicts.
4. **Uncovering hidden stakeholders and causes:** There are clear gaps in the

research, such as the lack of focus on the roles of women and youth in conflicts and the tendency to overlook certain root causes. A comprehensive framework would prompt researchers to explore these often neglected dimensions of conflicts and encourage more inclusive and holistic analyses.

5. **Integration of multiple disciplines:** Farmer-herder conflicts involve complex social, economic, political and environmental dynamics. A robust framework would encourage interdisciplinary collaboration, allowing researchers from various fields to contribute their expertise and perspectives, thus generating a more complete understanding of the conflicts.
6. **Guiding research focus:** The "cacophony" of causes can be overwhelming for researchers seeking to conduct studies. A well-designed framework would help researchers narrow their focus, guiding them to investigate specific interactions and aspects within the larger web of causes.
7. **Policy and intervention design:** An effective framework would aid researchers, policy-makers, practitioners and organisations working to address farmer-herder conflicts. It would provide a structured approach to designing interventions that target the underlying causes and dynamics rather than merely addressing symptoms.
8. **Visualising complexity:** The complexity of farmer-herder conflicts requires a visual representation to grasp the intricate relationships between causes and effects. A framework can provide a graphical model that facilitates clear communication of research findings to stakeholders and the broader public.

It is now important to use this framework to explore the reasons and causes of farmer-herder conflicts in more detail, without using the inflammatory language and labelling of specific groups described in the introduction. Only by doing this can we begin to understand the problem in a clearer and fairer way.

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Causes and impacts of farmer-herder conflicts through a political economy and food production lens. Case study in Gadarif State, Sudan

Gadarif State is located in eastern Sudan and is home to a wide range of pastoral groups rearing camel, sheep and cattle. The total number of animals in the state is estimated to be about 7.6 million heads. Pastoralism and smallholder crop farming are practised by the majority of the population in Gadarif State. Both pastoralism and smallholder crop farming are important components of the Sudanese economy and contribute to the livelihoods of a significant portion of the population. Livestock holds a prominent position in the nation's economy, making a substantial contribution of approximately 60 per cent to the agricultural gross domestic product, constituing around 25 per cent of the overall national gross domestic product.

In Gadarif State, farmer-herder conflicts have intensified since the mid-1980s due to several factors, including climate change, land use policies favouring large-scale agriculture and, most recently, an influx of pastoralists seeking refuge from conflict in neighbouring regions. The refugee pastoralists are mainly from Blue Nile State. Conflicts primarily stem from competition for diminishing resources like land and water, particularly along livestock corridors and in forest resting areas.

Farmer-herder conflicts disrupt food production systems for both farmers and herders. Farmers face crop losses due to animal trespassing, leading to food insecurity and economic hardship. Herders, burdened by fines and restrictions on movement, experience reduced herd productivity and resort to alternative income sources like wage labour and crop cultivation. Despite the significant role played by pastoralism and smallholder crop farming in the food security of the country and its exports, policy-makers in Sudan often overlook their contribution. The primary rationale provided for the consolidation of authority is to facilitate the expansion of large-scale agriculture, with the belief that pastoralism and smallholder crop farming are antiquated methods of food production. Consequently, the state allocated land for large-scale mechanised farming.

Both farmers and herders prefer informal conflict resolution through traditional leaders because of its efficiency and cultural appropriateness. Thus, the *ajawid* is the main mechanism for resolving conflicts between the two groups in the area. Ajawid is a traditional mechanism for dispute resolution where respected members of the community and traditional leaders, usually male elders known for their knowledge of communal and customary norms, get involved to reconcile the parties through compensation or forgiveness without the involvement of the formal state authorities. This process is not time- or money-consuming, unlike the formal state methods.

While women and youth bear the brunt of the farmer-herder conflict impact, they remain largely excluded from conflict resolution processes. Farmer-herder conflicts are expected to worsen as resource scarcity intensifies and competition for land increases. The ongoing war in Sudan further exacerbates the situation by limiting pastoralists' mobility and increasing livestock concentration in farming areas.

Hussein M. Sulieman, *forthcoming.*

Effects of sedentarisation policies

In many African and Asian countries, traditional systems of transhumance are viewed as backward, and partly, the governments pursue very strict sedentarisation policies. Describing the example of Benin, our authors demonstrate what this can lead to.

By Rodrigue V. Cao Diogo, Allogbénou S. Frimence Toussou and Saliou Adedigba

Sedentarisation refers to transitioning from nomadic or transhumant mobility to a more settled lifestyle. This has been a topic of interest in West Africa due to its impact on agricultural production, food security and poverty. Recently, West African governments have promoted several policies of livestock herd sedentarisation for several reasons. One of the underlying justifications is that both the colonial administration and the African governments regarded the pastoralist way of life as conflicting with farming and incompatible with the standard of civilised society. In a sadly recurring story, national governments often perceive the lifestyle of small foraging populations as impoverished, with cultural values detrimental to their welfare, leading to resettlement in new communities. However, it's essential to recognise that this process can have significant consequences, including the privatisation of resources and soil fertility decline in certain regions. The disappearance of specialised single agricultural activity farms and the emergence of integrated farms are also associated with sedentarisation. Overall, the motivations behind these policies are complex and multifaceted, involving economic, social and cultural considerations.

A Dinka child with a zebu cow. Loss of traditional livelihoods and social identity is one of the negative aspects of sedentarisation policies.

Photo: Jörg Böthling

The case of Benin

In northern Benin, cattle farms face feed scarcity and conflicts in the management of pastoral resources, including land. This led to the adoption of the new pastoral code (Law n° 2018-20 of April 23rd, 2019) regulating this activity and opting for the sedentarisation of livestock. In 2021, Benin's Office of the High Commissioner for the Sedentarisation of Livestock Breeders began implementing a sedentarisation policy to "modernise" traditional transhumance practices among herders.

The policy aims to provide a "unique model of alternatives to transhumance" while gradually implementing sedentarisation. Transhumant pastoralists have settled in Benin, partly due to droughts in the 1970s and as a coping mechanism in response to changing political economy. The government explicitly supports this sedentarisation agenda, which is largely embraced by pastoralist Fulani communities. In Benin, sedentarisation policies have been implemented to address farmer-herder conflicts. Farmer-herder conflict and transhumance in Northern Benin are deep-rooted in tensions between communities because of agricultural and animal breeding activities practised in the same areas. Historically,

farmers and herders in West Africa had symbiotic relationships. However, changes in the political economy of pastoralism, for example land reforms (ownership, access and use), agricultural development including mechanisation and land grabbing from herders, disrupted this relationship. The rapid demographic growth, urbanisation and industrialisation led to increased demand for food and agricultural produce. This expansion of agricultural land limited grazing and transhumance areas, threatening pastoral livelihoods. Addressing farmer-herder tensions and rethinking present policies is crucial. The current strategy seeks pastoralist sedentarisation but lacks a clear evidence-based approach. Benin's sedentarisation policy aims to transform traditional practices while recognising the complexity of Fulbe's livelihoods. However, addressing underlying issues and promoting evidence-based policies remain essential for sustainable conflict resolution.

Panicum production on a sedentary farm in Tchatchou, Benin.

Photo: Rodrigue Diogo

What are the effects of these policies?

The effects of sedentarisation policies on herders and their communities can be both positive and negative. The positive effects include:

- improvement of livelihoods where sedentarisation can lead to better access to services – such as healthcare and education – and economic opportunities;
- sustainable resource management, as controlled grazing may reduce environmental degradation and overuse of pastureland;
- conflict mitigation, as reduced mobility can decrease farmer-herder clashes in specific areas.

However, the policies can have some negative effects, such as:

- loss of traditional livelihoods – herders may lose their nomadic lifestyle, cultural practices, and social identity;
- land tenure challenges – implementing sedentarisation requires addressing land tenure issues, which can be complex;
- resource constraints – fixed locations may strain already scarce resources like water and grazing land.

The balance between these effects is important for successful implementation of sedentarisation policies.

How can conflicts between herders and farmers be resolved?

Meanwhile, policy-makers can take several steps to address the negative effects of sedentarisation on herders and their communities. These include:

- land tenure reforms such as securing land rights by ensuring that herders have secure land tenure, allowing them to access and manage land effectively and community-based approaches by involving the local communities in land management decisions to prevent conflicts;
- livelihood diversification through skills training by providing training in alternative livelihoods (e.g. agroforestry) to compensate for lost income and value-added activities by encouraging value-added activities related to livestock (e.g. dairy processing);
- infrastructure development: through establishing of water infrastructure (wells, boreholes) to support sedentary herders and through improved access to healthcare and education services;
- social services and cultural preservation by promoting cultural events, festivals, and traditional practices and strengthening social networks to mitigate isolation;
- conflict resolution mechanisms through ease of dialogues between farmers and herders to resolve disputes and by establishing clear legal frameworks for conflict resolution.

Lessons learnt from Benin

In Benin, new pastoral legislation has led to a reduction in transhumance areas for semi-mobile livestock farming and a densification of herds in the territories. It has resulted in an increased pressure on communal rangelands and therefore, in feed insufficiency in the different livestock farming systems, especially in the rainy season with difficult access to land. The expansion of agricultural areas, together with the corresponding cultivation techniques, considerably reduce grazing areas and give rise to antagonisms between breeders and farmers in the regions.

With the current dynamics in North Benin, significant flows of animals have been observed towards forest areas and low-pressure territories, which explains the decrease of more than 15 per cent in the cattle herd between 2013 and 2021 in this area. The application of the new provisions recommended by the law on the regulation of transhumance remains complicated for mobile breeders. The latter perceive these changes in animals mainly through the drop in milk production and significant weight loss. The sedentarisation programme (ProSer) in Benin intends to recommend new exploitation strategies based on the cultivation of forage species and the regulation of internal mobility. Despite these efforts, forage production is struggling to develop on farms and pasture degradation is increasing, exacerbating the conflict situation. But land availability and access to seeds constitute the real obstacles to fodder intensification. Particular attention must be paid to the mechanisms for removing these barriers for the success of the policy of sedentarisation of livestock farming.

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The untapped potential of protein diversification

Diversifying our protein supply to include plant-based foods and cultivated meat can be a game-changer for climate mitigation and climate adaptation, especially in the countries of the Global South. However, a great deal of research is still required to capitalise on this potential. And political support, as our author demonstrates.

By Ivo Rzegotta

Research by the UK's Oxford University shows that the world cannot meet its climate targets without shifting away from conventional animal agriculture. Today, intensified animal agriculture causes around 20 per cent of global greenhouse gas emissions – equivalent to all the planes, trucks, cars, trains and ships on Earth. Also, industrialised animal agriculture is the biggest driver of deforestation and the loss of biodiversity. Nevertheless, global demand for meat is growing. As people don't want to give up their favourite foods, we need to transform how meat is made, and make sure sustainable options are delicious, affordable and accessible. Complementary proteins, globally known as alternative proteins, are a rapidly growing area of food technology focused on pioneering foods that can provide viable alternatives to animal-derived meat, seafood, dairy, and eggs. These innovative foods taste the same as or better than conventional animal products with similar nutritional profiles. Examples of these new innovative foods include plant-based meat and dairy products and, in the long term, cultivated meat grown directly from animal cells.

Further research is needed to realise the potential of protein-rich plants such as red beans, black beans and mung beans.

Photo: Live and Learn/ shutterstock.com

A building block for more sustainable food systems

Diversifying the food systems to include these options offers new options for consumers, and new opportunities for farmers to deliver the high value crops and regenerative agriculture we need for the future. It is a necessary solution that works with existing consumer behaviours while reducing greenhouse gas emissions and freeing up land for nature restoration and more sustainable farming practices. Peer-reviewed studies show that shifting to plant-based and cultivated meat could reduce climate emissions by up to 94 per cent compared with farming animals – enabling people to eat their favourite foods without accelerating the climate crisis. Also, plant-based and cultivated meat could deliver the meat people want with up to 90 per cent less land (see Figure on page 38).

Complementary proteins reduce the pressures of intensification of livestock farming and the subsequent risk of outbreaks of animal diseases in such confined environments. Furthermore, plant-based meat and cultivated meat are antibiotic-free – so they can deliver meat without driving the problem of antimicrobial resistance and, therefore, protect lifesaving medicines.

These foods have the potential to serve as a tool for the sustainable industrialisation of agriculture, bringing economic and social development to countless rural family nuclei. They can be made with indigenous crops grown by small-scale farmers to suit the needs and tastes of local communities. In regions where protein and micronutrient deficiencies are still widespread, these foods could play a key role along with traditionally farmed protein sources to improve nutrition, reduce monocultures and safeguard local production.

Developing countries have been committing to increasingly ambitious climate mitigation and adaptation goals. But while the general debate on the need for sustainable food systems is gaining relevance, the potential of complementary proteins for food security goals and mitigating climate impacts is – at least for now – a largely neglected topic.

It is thanks to billions of euros in government investment that the cost of solar panels fell by more than 85 per cent between 2010 and 2020. However, protein diversification has received just a fraction of the public investment that has gone to other climate innovations such as renewable energies and electric cars, making this a particularly high-impact opportunity for governments that want to invest in a sustainable transformation. Just like they have funded research and development for renewable energy, governments should fund open-access research into plant-based and cultivated meat. Open-access research can help to make the technology available to everyone and thus prevent the emergence of new dependencies on the northern hemisphere.

Realising the potential of plant-based proteins

In the short term, it is primarily plant-based foods that can contribute to protein diversification in the countries of the Global South. Plant-based meat looks, cooks and tastes like conventional meat – but it's made entirely from plants, without the downsides of industrial animal agriculture.

Crop diversification is an essential component of creating a more secure, sustainable and just food supply. Today, the primary ingredients for plant-based meat world-wide are soy, peas and yellow peas. Soy-producing countries have spent decades optimising that crop and driving down costs through innovative breed-

ing programmes. As a result, producers have more than doubled how much value they get from every single acre of land. Similarly, cereal crops like wheat have nearly tripled their yield sizes over the past 50 years. However, there are many other plants whose potential for the production of plant-based foods has not yet been sufficiently explored. Mung beans have far lower allergenicity than either soy or wheat and are among the most heat-resilient of all legumes. Legumes like mung beans have increased by a comparatively meagre 60 per cent over the last decades. They have been woefully neglected by protein-focused research and development programmes.

Further research is needed to realise the potential of protein-rich plants. Besides mung beans, these include, for example, barley, canola, black beans, cowpea beans, chickpea, sesame and sunflower seeds. The plants that come into question are highly dependent on the respective local conditions. More research is also needed in the area of processing, for example on how off-flavours can be avoided in the production of plant-based foods and how products can remain "clean label" with just a few healthy ingredients.

Incentivising the private sector to establish supply chains for these crops, which can act as ingredients for plant-based meat, would also help to increase the cultivation of these crops and ensure consistent yields for farmers. Here is one example from Brazil. The Good Food Institute Brazil is currently running a project which aims to use beans to replace its cousin peas, which are imported from countries in the northern hemisphere in an already processed form, as an ingredient for plant-based products. The goal is to process the broken beans that are unsuitable for bulk sale, which are currently treated as animal feed waste, into a protein concentrate that could be sold directly to the plant-based industry. Producers would then have a new source of income, complementary to the sale of intact grain with high added value. Projects like this one contribute to reversing the country's age-old logic of exporting commodities with no added value and importing the grain back after processing.

Fostering open-access research in the field of cultivated meat

In the long run, cultivated meat can also significantly contribute to climate mitigation and climate adaptation in the Global South. Cultivating meat involves taking a small sample of cells from an animal and growing them in a fermenter, similar to those used for brewing beer. This supports the same process that happens inside an animal by providing the warmth and the basic nutrients needed to produce meat – water, proteins, carbohydrates, fats, vitamins and minerals. The result is ground meat, which can be formed into a range of final products that are indistinguishable from conventionally produced meat.

At present, cultivated meat is still at an early stage of development. It has already been authorised for sale in some countries, but is not yet being produced on a commercial scale. Prospectively, the countries of the Global South could play a major role here because cultivating meat requires energy, which can be abundantly harnessed from the ample sunlight available in many of these countries.

Additionally, as climatic conditions worsen for crop farming in many regions of the Global South, this new way of making meat can provide a more reliable alternative. In this way, protein diversification can help adapt to the impacts of climate change and enhance food security in vulnerable regions. For cultivated meat to become an impactful option for the Global South, more public investment is needed to lower the production costs significantly. To this end, governments around the world should particularly support open access research in this field so that innovations can be democratised and have a global impact.

A sensitive understanding of local contexts is needed

For plant-based and cultivated meat to be seen and accepted as a relevant food choice for most people, they have to shed their perception of a premium food option available to only the rich. They must offer comparable protein quality and nutrient density to be considered viable alternatives to animal-source proteins. And also, they must provide a fair path to transition for local farmers.

Protein diversification is not at odds with other approaches to a more sustainable food system. Regenerative agriculture, organic farming and complementary proteins all share a common goal: transitioning from industrial animal agriculture to a more sustainable system. Each of these approaches has its own role to play in creating a healthier, more sustainable and just food system. And by reducing land use, complementary proteins also create the conditions for these other approaches, which often require more land, to be successful.

The preconditions in individual countries vary greatly in terms of climate, soil quality, the availability of sustainable energy sources and workforce, and many other factors. Therefore, it is necessary to approach protein diversification with a sensitive understanding of the various local contexts, promoting inclusion and fostering collaboration for positive transformation towards food and nutritional security, economic development, food diversity and sustainability.

Environmental benefits compared to conventional meat

	Plant-based meat*	Cultivated meat*
GHG emissions (CO_2e)	Up to – 94 %	Up to – 92 %
Land use	Up to – 89 %	Up to – 90 %

* if produced at scale and with renewable energies

Source: Plant based meat: Sarah Nájera Espinosa et al. in Nutrition Reviews (2024); Cultivated meat: Pelle Sinke et al. in The International Journal of Life Cycle Assessments (2023).

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Getting change for climate action into food systems should start with the UN

Whereas attendance is growing with each new international climate event, this has hardly contributed to more being done to combat climate change. Our author argues that instead of spending millions on raising false hopes, the UN climate change process itself should undergo reforms aimed at genuine results.

Dhanush Dinesh is the Chief Climate Catalyst of Clim-Eat, a think and do tank for food and climate which he founded at COP 26.

Earlier this month, thousands of people travelled to Bonn for the UN's Bonn Climate Change Conference. It aimed to set the agenda for international negotiations at COP 29 in Azerbaijan in November and featured a flurry of side events, meetings and discussions. I'm told that over 10,000 people sought accreditation this year – far more than last year and far beyond the capacity of Bonn's World Conference Center. This is in keeping with ballooning attendance at such events. COP 28 in Dubai last year attracted a record-breaking 83,884 people (with badges). While it's great that so many people are keen to take action on climate change, this begs a more fundamental question: Do these conferences – and the UN negotiations they support – actually achieve anything substantive?

In a recently published peer-reviewed article, my colleagues and I decided to investigate. We tracked the progress of official negotiations on food and agriculture since 2006 – this was when the UN formally acknowledged the need for targeted action in agriculture, which both contributed to climate change and were likely to suffer from it. Surely, 17 years was enough time for some action to have been taken. But no. We found that these conferences have provided little more than false optimism and empty promises. Also worrying was the growing influence of special interest groups in hijacking official agendas. While we observed numerous steps in the process, like decisions, workshops, views of countries and organisations being submitted, and announcements, we haven't observed results. Little action was taken to reduce greenhouse gas emissions from agriculture and enhance farmers' resilience. Meanwhile, emissions from agri-food systems continued to rise, and increasing temperatures also posed significant challenges to food production.

We concluded that the process had taken over the purpose of the negotiations. Each year, we go through the motions of one conference after another, while actual progress on the issues these conferences were established to tackle has somehow been forgotten. We concluded that the UN climate change process had failed – at least in relation to food and agriculture.

The UN Bonn Climate Change Conference this year marked the 60th meeting of the Subsidiary Bodies of the United Nations Framework Convention on Climate Change (UNFCCC), which includes the implementation body (SBI) and the scientific and technological body (SBSTA). During the conference, formal negotiations on agriculture continued under the Sharm el-Sheikh joint work on implementation of climate action on agriculture and food security, which was established at COP 27. These negotiations concluded by agreeing on a work plan for this process. While settling for agreeing on a work plan after 18 months of stalemate might be considered a big win by some, my view is the contrary. The work plan essentially includes workshops, submissions and an online portal – how will these lead to real-world action? Such mechanisms have been tried again and again over the past 17 years, but they haven't resulted in real-world impact.

Meanwhile, outside the official negotiations, the COP 29 Presidency of Azerbaijan and the Food and Agriculture Organization of the United Nations showcased a new "special" initiative. Titled Harmoniya, it seeks to harmonise existing initiatives relating to agriculture; increase investments in climate action in agriculture; and support climate-resilient villages and communities. While these aims are commendable, if history and evidence is to be believed, this initiative will also be launched to much fanfare, applause and media attention, and forgotten soon afterwards. So while Bonn might signal progress in terms of climate diplomacy, my view is that we are investing in a failed process, which will continue to disappoint us.

This is a continuing source of anxiety for my colleagues and me, who have spent most of our professional lives working in agriculture and food systems. We've been involved in numerous scientific studies on climate change, and each year, we fail to see the very compelling results reflected in any tangible action taken via UN negotiations. That's why I believe continuing to invest time, money and hope in the UN's climate change process is a wasted effort. Instead, we should be calling for significant reforms. Based on our findings, we suggest:

- The UN focuses on measuring results and the impact delivered from climate change negotiations. Specifically, the UNFCCC – the agency that convenes negotiations – needs to stop acting as a "mega-meeting" organiser and become a watchdog that ensures action by state and non-state actors.
- The annual climate change COPs should be made leaner. In a world starved of climate finance, spending hundreds of millions of euros on meetings each year is unacceptable. Germany and the UK spent over 100 million euros and 300 million euros for COP 23 and COP 26, respectively. We suggest that the COPs be scaled down to receive fewer participants and organised every two years instead. They should focus on working meetings that deliver results instead of being de facto trade fairs that give false optimism to the wider public.
- Transparency on the costs, participation and emissions of the COPs themselves is needed to ensure that the UN is more accountable to the public. This is also crucial to protecting the UN process from the influence of host countries' priorities, lobbyists and private consultancies.

With just a few more months to go to COP 29 in Azerbaijan, it is important to learn from the failures of the past, and truly rethink and reform the process for systemic change for climate action in food systems. More of the same unfortunately will not deliver different results.

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A coast fisherman drying fish at the beach in Nagapattinam, Tamil Nadu, India.

Addressing post-harvest challenges in aquatic food systems

In the coming years, the demand for aquatic food is set to further rise. It is all the more important to minimise the huge losses incurred along the value chain. But to achieve this, they first of all have to be accurately established – not an easy venture, as the WorldFish experts demonstrate.

By Aditya Parmar and Cristiano M. Rossignoli

Aquatic food systems play a crucial role in global food security and nutrition, providing nearly 20 per cent of animal protein for over three billion people. Beyond this, these systems underpin the livelihoods of approximately 800 million people world-wide, offering opportunities for inclusion, social equity and jobs. The majority of these people live in developing countries, and are responsible for over 50 per cent of the world's traded seafood. Aquatic foods, encompassing both plants and animals grown in or harvested from an aquatic environment, are especially crucial for many vulnerable communities world-wide, serving as the primary source of essential nutrients where alternative nutrition sources are scarce.

The significance of aquatic food systems extends beyond mere nutrition and livelihoods; they are integral to achieving broader socio-economic objectives, including poverty alleviation, gender equity and environmental sustainability. The United Nations Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 14 (Life Below Water) and SDG 12 (Responsible Consumption and Production), underscore the importance of sustainable aquatic food systems. Strengthening these systems through innovations in aquaculture, fisheries management and equitable policy frameworks can catalyse a transformative shift towards a more sustainable and food-secure world.

The growing demand for aquatic food

Globally, the demand for aquatic food is on an upward trajectory, with projections indicating a potential doubling by the year 2050. Current global consumption of marine food is approximately 80 million tonnes in live weight annually. However, according to estimates from the Food and Agriculture Organization of the United Nations (FAO), this is expected to surge to almost 155 million tonnes across all fish and shellfish categories in the next three decades, contingent on sustained production growth and stable prices.

Here are some key points regarding the global demand for aquatic foods and its impact on fish stocks and communities depending on them:

- Most of the recent growth in demand comes from Asia. China is anticipated to continue being the world's largest fish consumer.
- There is a notable dietary transition in sub-Saharan Africa, where demand has outpaced supply.
- Future increases in demand are likely to be met almost exclusively from aquaculture, which is predominantly situated in Asia.

Photo: Jörg Böthling

- While improvements in livestock production have been made and recognised, the potential for expansion in aquatic food production remains vastly untapped. As national incomes rise in many countries, demand has shifted towards less environmentally sustainable aquatic foods like salmon and shrimp due to changing tastes among higher-income earners. However, the consumption of freshwater fish and bivalves remains strong.
- According to the World Resources Institute (WRI), over a third of marine fish stocks are overfished, with more than 60 per cent fished at their maximum sustainable limits, stressing both the marine populations and the communities dependent on them.

Weaknesses of current estimates of fish post-harvest loss and waste

Despite the global abundance of fishery resources, significant post-harvest loss and waste poses a major challenge to realising their full benefits. These losses can be particularly significant in low-income countries, where drivers of losses are less controllable, and the resources to reduce them are limited. Quantifying fish loss and waste presents significant challenges due to a lack of uniformity in measurement methods and significant variations among species, production technologies, geographic origin and value chain stages. Moreover, the existing body of literature on the losses, primarily consisting of ad-hoc case studies, often suffers from significant gaps because lack of resources generally constrains these studies. Also, they focus only on certain stages of the value chain – mainly production and consumption – leaving part of the processes under-studied. Furthermore, the scarcity of post-harvest data on aquaculture leads to uncertain estimations and rough general conclusions drawn from a handful of studies whose findings are extrapolated at national and international levels. The lack of accurate contextual information at the local level is directly linked to limitations in devising measures, plans and strategies to reduce the losses. Accurate and contextual information, however, is critical for policy-makers, planners and researchers to make informed decisions and for the development of targeted interventions to minimise fish loss and waste across the entire value chain.

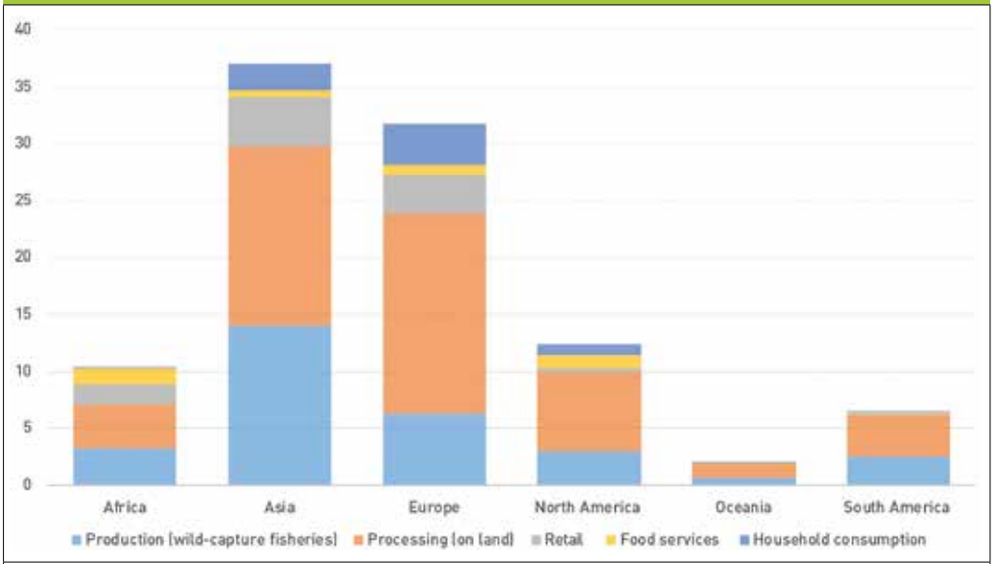
A widely cited FAO 2011 report estimates that 35 per cent of aquatic foods are lost and wasted world-wide, a level higher than those of cereals (30 %), oilseeds (20 %) and meat and dairy products (20 %). These estimates were based on the assumptions that aquatic food losses stem only from capture fisheries and occur primarily during regional production, and thus failed to account for com-

Loss and waste in small-scale fisheries

Small-scale fisheries constitute a significant portion of the fishing activities in developing countries. For instance, in sub-Saharan Africa, the majority of the fishing industry – exceeding 90 per cent – is characterised by artisanal practices and informal trade networks. The availability of data pertaining to small-scale fisheries, particularly concerning FLW of aquatic products, is notably scarce. The World Economic Forum (WEF) highlighted in its 2014 report that the estimates of post-harvest fish losses within small-scale fisheries varied widely, from 20 per cent to 75 per cent. Such a substantial variance underscores the challenges associated with data acquisition in the small-scale fisheries sector, which is marked by a high degree of diversity in its operational methodologies and the mechanisms through which aquatic foods are lost or wasted.

plex global trade dynamics and the nuances of local consumption patterns, i.e. they lack the accuracy of direct measurements at the household level. An updated FAO report released in 2019 merged data for aquatic food with other animal products, hindering specific challenges faced in and analysis of aquatic food loss and waste (FLW). A recent report (2024) from the World Economic Forum (WEF) provides more updated information on the global aquatic FLW across different nodes of the value chains (also see Figure). The report reveals that globally, 23.8 million tonnes of aquatic food was lost or wasted in 2021, which represents about 15 per cent of the global production. However, the analysis from WEF does not include FLW associated with processing at sea, aquaculture and small-scale fisheries.

Estimated proportions of aquatic food loss and waste at each node in the value chain in 2021



In per cent; the figures do not include small-scale fisheries. Source: WEF, 2024.

In the current literature, food loss in aquatic foods is typically broken down into four groups: physical loss, quality loss, nutritional loss and market force loss. However, for simplicity, it can be broadly categorised into two types: quantitative and qualitative losses. Quantitative losses refer to the actual reduction in the number of fish available for consumption due to spoilage, discards during fishing, accidental loss during handling and transportation issues. These losses not only reduce the food available for consumption but also affect the economic viability of the aquatic food system. Qualitative losses pertain to the deterioration in the nutritional value, texture, flavour and overall acceptability of fish. Factors contributing to qualitative losses include improper handling, inadequate storage, and failure to maintain optimal temperature conditions. Such losses, while not constantly reducing the physical quantity of fish, diminish its economic value and can adversely affect health and nutrition.

Food dynamics

Adopting a food-focused approach allows for a deeper understanding of the social, economic and nutritional impacts of losses and waste. This perspective considers:

Social impacts: how food losses and waste affect food security, livelihoods and cultural practices related to fish consumption and conservation especially in communities heavily dependent on fisheries.

Economic impacts: This includes the financial losses to fishers and farmers, processors, retailers and consumers, along with broader economic implications for local and global markets. Sometimes also called market force losses, these happen when there is a mismatch between the supply and demand of fish, causing price fluctuations.

Nutritional impacts: The analysis of dietary losses due to FLW, particularly in regions reliant on fish as a primary protein source, highlights the significance of addressing FLW for public health. For example, certain heat-sensitive nutrients, such as essential amino acids (lysine), can be altered or damaged during hot smoking, a method commonly used in many African countries.

Environmental impacts: The waste generated from overfishing, discarding, or spoilage of fish contributes to methane emissions during decay, escalates fuel usage along the supply chain and depletes critical resources, thereby adversely affecting the environment.

Drivers of fish loss and waste along the value chains

Food loss and waste in aquatic food systems stems from a variety of factors, including inadequate cold storage facilities, inefficient transportation, technological gaps and lack of training for fishery workers. These issues are exacerbated by fluctuating market demands and insufficient regulatory frameworks, affecting developed and developing nations. It must be noted that 40 per cent of the aquatic foods world-wide (about 70 million tonnes) is sold live or fresh and is highly perishable if not preserved in some form. This large proportion of fresh aquatic foods is due to their high retail value compared to frozen, dried or smoked produce. But the fresh fish value chain requires a robust cool chain. Moreover, the very nature of aquatic food (characteristics like smelling when not cooled, for example) can cause food safety concerns among consumers, leading to more losses at the market level.

Diving deeper into the specific stages in the supply chain where losses occur will offer insights into the dynamics of these losses and wastes and help identify hot spots that can be targeted to get maximum impact. The typical fish value chain stages and critical drivers of loss and waste are as follows:

Catch stage or primary production: Losses at this stage may result from by-catch (non-target species caught and discarded), damage due to improper handling and spoilage on fishing vessels because of inadequate storage facilities.

Transportation: This stage is critical, especially for perishable products like fish. Losses occur due to delays, lack of refrigeration and rough handling during transport from the fishing area to processing units or markets.

Processing: At the processing stage, losses can result from inefficient processing techniques, equipment failures, or suboptimal processing conditions, leading to spoilage or downgrading of fish products.

In sub-Saharan Africa, the majority of the fishing industry – exceeding 90 per cent – is characterised by artisanal practices and informal trade networks.

Photo: Jörg Böthling

40 per cent of the aquatic foods world-wide is sold live or fresh or live is highly perishable if not preserved in some form. Photo: Sunil Siriwardena

Storage: Inadequate storage facilities, poor inventory management and failure to maintain appropriate environmental conditions can lead to significant losses.

Retail and consumption: At the retail level, waste can occur due to overstocking, cosmetic standards rejecting perfectly edible fish, and consumer preferences. At the final consumption stage, household food waste includes discarding edible fish parts and spoilage because of improper storage.

A detailed understanding of where and why losses occur enables the development of targeted interventions at each stage of the food system. These interventions may include:

Technological innovations: Developing and deploying technologies for better storage, processing and transport can significantly reduce physical and quality losses.

Policy and regulatory measures: Implementing policies that support sustainable fishing practices, reduce by-catch, and improve food safety standards can address systemic issues leading to FLW.

Consumer education: Raising awareness about sustainable consumption practices and the importance of reducing food waste can help mitigate losses at the retail and consumption stages.

Stakeholder collaboration: Engaging all stakeholders, from anglers to consumers, in collaborative efforts to reduce FLW ensures that solutions are comprehensive and sustainable.

Developing a comprehensive framework to reduce fish loss and waste is critical, which in turn helps towards more sustainable fisheries management, improved food security and reduced negative environmental impacts. By focusing on the entire food system and the specific stages where losses occur, targeted solutions can be developed to address this global challenge effectively. Significant losses often occur during processing when various parts of fish remain unused – skin, bones and fish heads, which are mostly discarded. These by-products (also known as wastes) and losses (unintentional losses) can sometimes represent up to 70 per cent of fish. This highlights a major area for improvement.

In conclusion, addressing this challenge in the aquatic food sector is not only about reducing post-harvest losses and wastes but is integral to enhancing the sustainability of global food systems, protecting marine ecosystems and supporting the livelihoods of communities world-wide. Through concerted and coordinated efforts across sectors, there is potential to make significant progress in transforming how we catch, process and consume aquatic foods, ensuring long-term food system resilience. By aligning these efforts with international sustainability goals, including SDGs 12 and 14, we can ensure a more sustainable and prosperous future for fishery-dependent communities globally.

Gathering comprehensive data on small-scale fisheries will contribute to a more holistic understanding of aquatic losses and wastes and help make effective and practical interventions to combat them. Moreover, species-specific information remains a persistent issue, which is vital for effective management of post-harvest losses. The Asia–Africa Blue Tech Superhighway (AABS) project, led by WorldFish, aims to bridge some data gaps in small-scale fisheries across countries, including Kenya, Tanzania and Mozambique.

Aditya Parmar is a post-harvest scientist in food loss and waste at the Sustainable Aquatic Food Systems programme at WorldFish. His work revolves around measuring food loss and waste and devising climate-smart and pro-poor technical and management interventions in the Global South to reduce these losses.

Cristiano Rossignoli is WorldFish's Monitoring, Evaluation and Learning (MEL) and Impact Assessment Research Leader. He also leads the CGIAR Aquatic Foods Initiative. He has a background in agricultural economics and sustainable aquaculture – his work aims to enhance livelihoods, nutrition, and food security in the blue food economy.

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References: **www.rural21.com**

Hot, colourful and remunerative

Kampot pepper is regarded as the "champagne" among pepper varieties and is held in high esteem by the world's gourmets and chefs. It is grown in accordance with stringent quality requirements in the Cambodian province of Kampot. That it is worthwhile for smallholders to grow this pepper too is also due to the French Social Enterprise Farmlink.

By Klaus Sieg

Chang Deang wipes his hand on his worn working trousers. He carefully takes one of the pinnacles with the green corns, plucks a number of them and lays them on the palm of his hand, from which he just got rid of the sticky reddish soil. "Try some, they're really hot," the farmer says with a smile on his haggard face. "We often cook using the young, green pepper," the 67-year-old from the Cambodian province of Kampot explains. "We like it best with shrimps and rice noodles."

Farmer Chang Deang plucking some corns from one of his 300 pepper plants.

Photos: Martin Egbert

The heat sensation rapidly spreads throughout the entire oral cavity. But there is so much more: the taste of citrus fruits and thyme, of minerals and a bit of eucalyptus as well as fresh greens. Chang Deang watches his counterpart's response in a friendly, quiet manner. He is aware of how special his pepper is. After all, this is the third generation of the plant he is growing. Every day, he walks along the rows of up to five-metre-tall plants two of which always wind their way around a wooden stake. Depending on the season of the year, Chang Deang prunes the plants, checks them for pests, loosens the soil and fertilises and irrigates it. "In the dry season, I have to do all that every second day. The pepper plant needs a lot of water," Chang Deang explains. For this purpose, he has dug a pond in which he gathers the rainwater over the months. Then, between March and June, harvesting is in progress nearly every day. Together with his son-in-law and his two daughters, Chang Deang does all this exclusively by hand. This ensures the product's high quality.

Popular with chefs and hobby cooks

Kampot pepper is said to be the best pepper in the world. Chefs and hobby cooks alike swear by this spice originating from southwest Cambodia. The quantities produced there are relatively modest. Only 300 pepper plants are growing on Chang Deang's farm, which itself is hardly bigger than half a soccer pitch. "Last year, I was just about able to harvest 240 kilograms – and that was a good year!" he notes. The entire province of Kampot turns out an annual harvest of slightly below 80 tonnes. On average, an individual plant will yield barely more than a kilogram of pepper. By contrast, in Vietnam, at 220,000 tonnes a year the largest producer world-wide, four to five times as much can be obtained from a single plant. This low level of availability is another aspect that makes Kampot pepper so sought after.

However, its biggest asset is its special quality, which is ensured by the traditional cultivating methods of the mainly small farms, the very humid and warm climate close to the coast in the Gulf of Thailand and the soils, which are highly penetrable and rich in mineral content. Also, the pepper in Kampot often thrives on old plants which have grown very deep roots. Furthermore, chemical fertiliser and pesticides are forbidden. Chang Deang exclusively uses cow dung and guano as fertiliser. The farmers gather bat droppings with tarpaulins they spread out under the trees from which the animals are hanging. Other farmers also make fertiliser with cow dung and grinded cattle bones or prawn husks. Chang Deang keeps pests at bay with slurry made of neem or tobacco.

Most of these rules are prescribed by a set of regulations adopted by the Kampot Pepper Promotion Association (KPPA), in which nearly 350 producers from the region are organised. Only they may refer to their product as Kampot pepper. Although the relatively large La Plantation, a model farm well-known for its agro-tourism which produces roughly a third of all Kampot pepper, also belongs to the Association, the majority of the producers manage farms the size of Chang Deang's. But how can these small farmers, many of who have had only little or even no school education and have usually never left their villages, conquer the kitchens of this world?

Market access and fair prices

This has a lot to do with Sébastien Lesieur. "I was familiar with the pepper from Kampot through my grandmother in France," the 44-year-old Frenchman wearing round glasses and short grey hair explains, sitting at a wooden table in a villa on the outskirts of Kampot, the seat of his Social Enterprise Farmlink. Jars with red, white and green pepper are standing on the table. Tall hibiscus bushes are blossoming in front of the window, while mango and neem trees offer shade.

Sébastien Lesieur founded Farmlink in 2005.

Sébastien Lesieur has been living in Cambodia for more than 20 years. Before that, he had been employed as a communications technology engineer in Paris. Boredom and gloom caused him to move to Southeast Asia, where he initially worked in development cooperation in Cambodia. Then he founded Farmlink. This company processes and markets pepper from up to 80 small-scale producers from the region. It helps farmers improve cultivation and with providing finance for the harvest. But above all, it creates access to markets in Europe for them and pay a fair price. "We pay the Farmlink farmers twice as much as the other merchants and processors in Kampot and ten times as much as what a pepper farmer gets in Vietnam," Lesieur explains.

It was also the French who, as a colonial power, introduced the cultivation of pepper in Kampot in order to meet their domestic demand. More than half of the total 8,000 tonnes of Kampot pepper harvested in the region at the beginning of the 20th century was shipped to France. There were still around a million pepper plants in Kampot in 1960. In 1975, all this met with an abrupt end when the Khmer Rouge established their reign of terror, claiming the lives of up to 2.2 million Cambodians after a long period of civil war. The pepper plantations were turned into rice paddies with forced labour, and fell into oblivion. Although the Khmer Rouge were all but ousted when the Vietnamese invaded the country, they managed to hold their own as a guerrilla army in some regions and provinces, also in the mountains of Kampot. It was not before the end of the 1990s that this small country with what are today just under 17 million inhabitants finally found peace. Since the 2000s, the revival of pepper growing has also been spreading in the province. So, founded in 2005, Farmlink was there virtually right from the start. The number of farmers represented and the quantities of pepper vary from year to year, although overall, sales have risen substantially. "Ten years ago, we still had harvests of five to six tonnes, and today we are marketing more than 20 tonnes a year," Lesieur says. So Farmlink brings a quarter of the entire harvest from Kampot to the rest of the world. The gourmet pepper goes mainly to France and Germany, although Farmlink also sells the hot peppercorns to the USA and Australia.

Strict quality controls

No matter where the pepper is exported to, thanks to precise documentation, every margin can be traced back to the individual smallholder. Everything is meticulously processed at Farmlink. In front of Sébastien Lesieur's office, staff are spreading out black pepper on long tables in the garden to dry it. They have previously washed it and ridden it of germs in hot water. "Steam would be too hot, and would harm the aroma," Sébastien Lesieur explains. Drying the pepper takes several days. In the evening, the staff heap up the pepper again and store it by hand. The following day, they once more spread it out, again and again sorting out bad peppercorns.

Drying the pepper takes several days. In each round, bad peppercorns are winnowed out.

When the drying is finished, before the packaging of the goods starts, there is another, final quality check. In one of the villa's rooms, staff wearing white overalls and masks are sitting testing the corns with tweezers, with which they also clip off some of the few remaining stalks. In this manner, up to a fifth of the harvest is once again sorted during processing. Sébastien Lesieur examines a plate of black peppercorns. In Khmer, he gives instructions and cracks jokes with the staff. The atmosphere is casual, and Farmlink also pays its staff well. In addition, they only work five days a week, not the country's usual six.

Just like with other varieties, there are three different types of pepper from Kampot. The pepper berries are ripe once their skin is coloured red in the pepper bush. If they are only harvested at this stage, their hotness will be balanced by their sweetness. Moreover, they have a fruity taste and are very suitable for salads or soups. Black pepper is gained from the green berries which are unripe when harvested, dry in the sun for some weeks and gradually change colour. This pepper tastes hot and strong, making it best suited for meat dishes. White pepper has its skin washed off, giving it a piquante, sour flavour.

Chang Deang's farm, on which he was already working as a child, used to be situated further back in the mountains. It was destroyed by the Khmer Rouge. He would rather not go on talking about this, and prefers to recall how he took up the tradition again more than 20 years ago. Since then, things have been improving steadily, above all thanks to Farmlink. "We can pay helpers, and we have bought a motorbike, a small tractor and a pump for irrigation," he happily says. "In addition, we have redecorated the house and bought new furniture." The family grow rice and vegetables for their own consumption. But income is earned with the pepper. Then Chang Deang hands us a couple of green peppercorns. Pepper from Kampot does everyone good, including the smallholders. And of course it delights the taste buds.

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Towards agroecological food systems transformation – experience with TAPE

Agroecological food system transformation has been identified as one solution to repair the broken global food system. However, in-depth evidence of the agroecological status, based on the ten elements of agroecology, remains sparse and often project or region specific. Here we provide a first glimpse across the globe of the vast diversity of agricultural production systems and their agroecological transformation, based on data derived with the Tool for Agroecology Performance Evaluation (TAPE).

By Lutz Merbold, Rémi Cluset and Anne Mottet

In order to ensure food security and nutrition world-wide, a fundamental transformation of the agricultural and food systems is necessary. Currently, our food systems, especially the most intensive ones, contribute to harming natural resources, including land and water. At the same time, many forms of food production around the world do have positive roles in ecosystems preservation and restoration. As an example, besides contributing to climate change via greenhouse gas emissions, agricultural production is tremendously harmed by climatic extremes and also critical in climate change mitigation via reduction of greenhouse gas emissions and carbon sequestration in soils and biomass. Less intensive agricultural systems, as predominantly found in low-and-middle income countries (LMICs) suffer from nutrient limitation and poor access to finance and markets despite being the backbone of the food supply for up to 85 per cent of the global population. Consequently, agricultural systems are far from functioning at their optimum across the five sustainability dimensions (environment, social and cultural, economic, health and nutrition, and governance), and agroecological transformation is envisioned as a contribution towards meeting the relevant Sustainable Development Goals, including the aspects of food security and nutrition, by 2030.

A small farmer in Kisumu County, Kenya, receiving advice on crop diversity for healthy nutrition. Diversity and knowledge-sharing are two of the ten elements of agroecology.

Photo: Jörg Böthling

Assessing the agroecological status-quo of farm systems

In essence, agroecological transformation is the sustainable modification of existing agricultural systems by ensuring the protection of biodiversity and natural resources through the co-creation and sharing of knowledge and more widely ensuring the fulfilment of the ten elements of agroecology published by the UN Food and Agriculture Organization (FAO) in 2018. One could imagine that such a transformation would automatically imply a reduction of current agricultural production, since the drivers that helped to increase agricultural productivity in the first place led to the currently observed non-sustainability with subsequent negative consequences. Already since the early 21st century, available intensification practices such as the use of industrially produced mineral fertilisers and pesticides, intensified irrigation measures or the decoupling of crop and livestock production resulted in fewer opportunities for circular agricultural systems. Often the key criteria for assessing the performance of agricultural systems were yields – not even the quality of yield harvested – while nutrition as well as other impacts such as environmental or social externalities were being treated as consequences that have to be dealt with downstream. Thus, holistic assessments – encompassing economic, ecological and social dimensions of agricultural systems and the identification of policy barriers have been proposed as the most promising way forward. Still, in-depth data on the agroecological status-quo of farm systems across countries and also where these systems can or should improve remains lacking.

There are plenty of publications available that describe the theoretical approach of agroecological food system transformation and yet only very few studies have shown specific data on what this could look like. Here, the

Tool for Agroecology Performance Evaluation (TAPE), launched in 2019, offers a good approach (see Box on page 48). So far, TAPE has been piloted and applied in a wide range of projects across 54 countries and in more than 10,000 farms, allowing for some preliminary analysis and lessons learned.

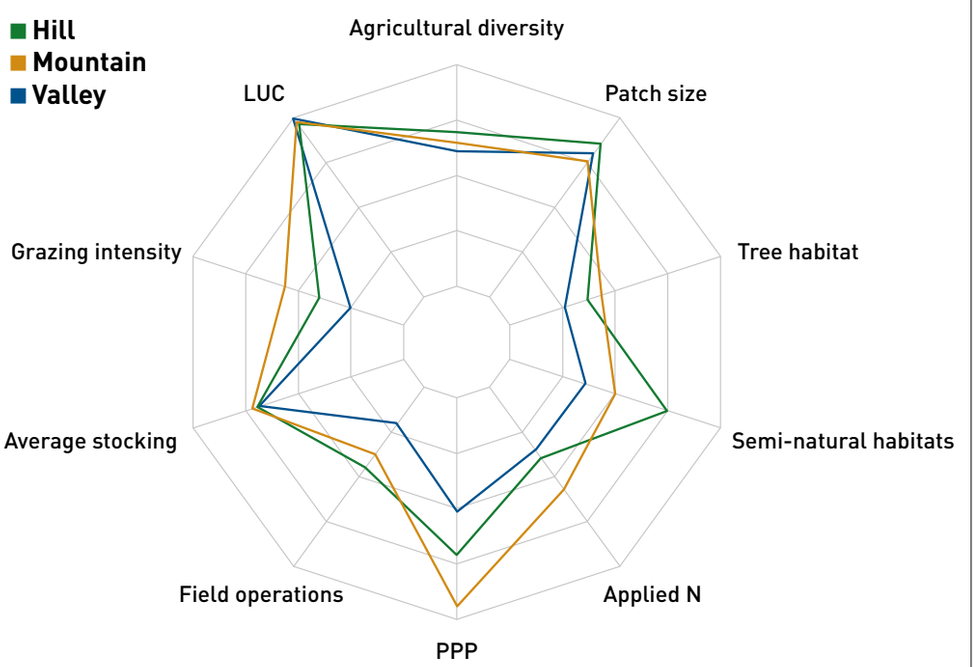
What TAPE studies have revealed so far

The studies available so far are mostly project specific and focus on individual countries or specific indicators, allowing a preliminary assessment of the potential of TAPE. For instance, in Mali, it was shown that more agroecological farms produce more and generate more income with less use of external resources. Moreover, agroecological farms use fewer pesticides, show better soil health, are higher in biodiversity, have access to local and territorial markets and bear clear advantages regarding youth empowerment. In Switzerland, a pilot of TAPE not only allowed modifying the Tool to be applicable in high income countries but enabled a comparison of strengths and weaknesses between regions. For instance, it has been shown that farms in the mountain regions are performing better than the valley farms in terms of biodiversity thanks to their absence of pesticide applications and lower stocking rates. At the same time, farming systems located in between the mountains and valley regions are more diverse in semi-natural habitats, such as hedgerows (see upper Figure). However, the valley farms are more productive and economically more resilient due to diversification. In addition, applying TAPE in countries where multiple other data streams on agricultural performance are already available enables improvements in specific indicators within TAPE. In this individual case, Agroscope – the Swiss Federal Excellence Centre for agricultural research – developed an advanced biodiversity indicator for TAPE. The new indicator takes ten drivers of biodiversity into account and allows assessments of biodiversity across the farm boundaries and beyond current agrobiodiversity (see upper Figure).

During a TAPE validation workshop at the Food and Agriculture Organization (FAO) in April 2023, first results from a dataset encompassing more than 3,000 farms in 40 countries were presented. The global dataset showed the widespread use of TAPE and enabled a distinction between the actual status of TAPE application and the purpose of its application in specific countries. This included pilot projects, support to baseline assessments of agroecological transformation for both donors and UN agencies and NGOs and projects that assist in developing the Tool further (see lower Figure).

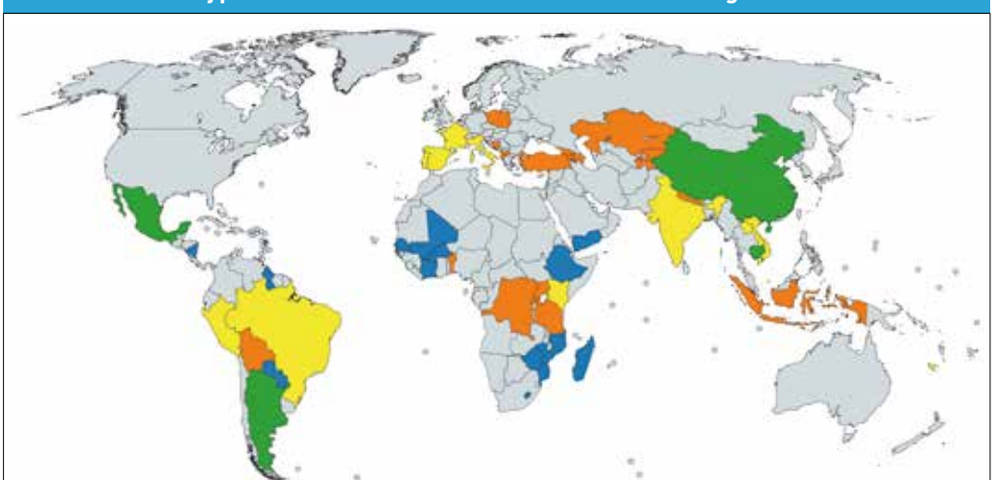
The global dataset, containing all the individual project data that were shared with FAO, enabled the provision of some basic overview on how agricultural systems differ between continents, for instance how farming systems rely on livestock. Thereby livestock – even though controversially debated given its large environmental footprint and the concerns of animal welfare particularly in intensified and specialised farming systems – is part of the solution for

The ten core criteria driving biodiversity across farming systems distinguished for three regions with differing farming systems in Switzerland



The higher the score, the better the performance of the criteria and, consequently, for biodiversity. For instance, mountain regions are better for biodiversity because of the absence of plant protection products (PPP). In contrast, the hilly areas perform better thanks to their diversity in semi-natural habitats such as hedgerows.

Overview of the type of studies where and how TAPE was being used



- Piloting phase funded by FAO
- Support to project baseline, M&E, impact evaluation (FAO, IFAD, GEF)
- Support to project baseline, M&E, impact evaluation (NGOs)
- Continuous development of TAPE with researchers and academia

Source: TAPE Validation Workshop Rome 2nd–3rd May 2023.

agroecological transformation when integrated with crops and trees. Livestock is not only essential for supporting livelihoods in LMICs, it further contributes to a farms diversity – a key contributor to the Characterization of Agroecological Transition (CAET) score (see Box) – and promotes better circularity of nutrients within farming systems. Besides that, there are vast amounts of agricultural land that allow livestock keeping only – including the central Asian steppe ecosystems, the savannah systems in Africa or even the sub-alpine meadows in the Alps. In-depth analysis is currently being undertaken for individual projects, and foreseeable results will enable an identification of specific entry points for agroecological transformation at farm level.

What is next?

Agroecological transformation is key to a sustainable agricultural and food system. TAPE results currently provide a snapshot and thus baseline information on farm systems in individual regions at project level. We identified a minimum of five areas for further improvement of TAPE, which need to be considered to unleash the full potential of the tool. This became particularly obvious during the pilot phase, when the tool was used for many more purposes than initially planned, including project design or project evaluation.

First of all, TAPE should be used ex-ante, such as in project design, aiming at assessing agroecological transformation, and not only ex-post analysis. This way it is possible to reliably assess the impact of individual interventions and provide the necessary robust evidence for decision-makers in the future.

Secondly, a TAPE survey should be carried out at regular intervals – not necessarily just once during the project duration, but each year or each second year if possible. Through such an approach, the agroecological transformation can be traced over time. Barriers for repeated surveys are small, especially since updating an existing questionnaire only needs limited efforts compared to establishing a baseline

Thirdly, agroecological projects should aim at going beyond the farm scale and include consumers and retailers to cover the full agricultural and food systems. Consequently, this also means that TAPE may be further developed to capture consumer behaviour.

The **fourth** area of improvement includes the development of new additional indicators – such as a potential climate score to include climate change mitigation co-benefits or trade-offs of agroecological transformation at farm level. It needs to be noted that the validation of existing indicators is also part of the future development for TAPE.

A **fifth**, and likely the most challenging development of TAPE, is its applicability at national scale. Besides an example from Brazil, where basic census data was used to perform Step 1 of TAPE, most projects so far focus on specific regions or were part of specific projects which does not necessarily allow drawing conclusions at national scale.

Many of these areas for future development are already being tackled and highlight the usability and support of the tool globally. Each of these five areas of improvement requires standardisation with regard to data collection by a variety of enumerators and in-depth data quality and data assurance steps. Only if these steps are thoroughly implemented can reliable and robust analysis across projects, regions and countries become possible. Partnerships are key to achieving these objectives, and the continuous involvement of farmers' organisations, NGOs, development agencies and academia in the tool development and deployment is crucial. For instance, the pilot testing of a digital platform in the context of the CIFOR-ICRAF-led MAP (Measuring agroecology performance) project to tailor the tools to users' individual needs and provide better support to users (from data collection to data visualisation or data access) and the forming of a Community of Practice of TAPE – under the Transformative Partnership Platform on Agroecology (TPP Agroecology) – is a promising step towards such future applications. This movement, which is currently growing, will be one useful element in driving the agroecological transformation of our food system forward.

Assessing agroecological transformation

The Tool for Agroecology Performance Evaluation (TAPE) has been designed in order to consolidate global evidence on how agroecology supports the transformation to more sustainable agricultural and food systems across five dimensions of sustainability: (i) environment, (ii) social and cultural, (iii) economic, (iv) health and nutrition, and (v) governance. It has been developed based on a mandate of 197 countries to FAO and was launched in 2019. TAPE focuses on deriving farm level data bases on household surveys with the opportunity for upscaling. Results are usable for multiple actors, including farmers, researchers, decision-makers as well as project evaluators.

The Characterization of Agroecological Transition (CAET) score aims at characterising the degree of transition to agroecology of agricultural systems. The ten elements are used as a criteria to define semi-quantitative indices that take the form of descriptive scales with scores from 0 to 4. Each element is described with three or four indices, resulting in a total 36 indices which are used to calculate CAET.

In parallel to TAPE, various other initiatives aim at assessing agroecological transformation. Examples include the European Partnership "Accelerating Farming Systems Transition: Agroecology Living Labs and Research Infrastructures", which is an ambitious, large-scale European research and innovation endeavour launched earlier in 2024. Another initiative is the Agroecology Coalition, which aims at facilitating co-creation and exchange of knowledge, promoting increased investments in agroecology and seeking political engagement and increased commitment to the agroecological transformation. In addition, there are many national initiatives focusing on agroecological transformation. A third example is the Transformative Partnership Platform on Agroecology (TPP Agroecology). Still, a global assessment using a similar approach is lacking. The diversity of approaches and tools contributes to enhancing our knowledge of agroecological assessment. Consolidating and harmonising these findings has become critical, and the effort of the global community built on TAPE can help.

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Alternative organic resources for soil health in Africa

Addressing soil health is recognised as a key strategy to improve fertiliser efficiency, and this is particularly important in Africa, where fertiliser is a scarce resource. Our authors have established the potential contribution of externally sourced organic fertilisers and biofertilisers in the context of a scoping study.

By Pierre Ellssel, Stéphanie Saussure, Fortunate Nyakanda and Bernhard Freyer

Achieving and maintaining high soil productivity and crop yields requires investing in soil health. Organic inputs offer a means to reconnect carbon and nutrient supply, a crucial aspect for optimising crop response to nutrients. On-farm adjustments in organic matter management, such as implementing proper crop rotations with legumes, agroforestry practices like alley cropping, utilising compost and animal manure, and adopting appropriate soil tillage practices are pivotal for maintaining soil health and effective nutrient management. In addition, off-farm produced organic fertilisers recycled from organic wastes can serve as valuable resources for composting and bioslurry production, addressing carbon and nutrient deficiencies in soils. Their proper utilisation not only benefits farms but also alleviates environmental and public health burdens associated with their mismanagement in many regions.

Biofertilisers (based on fungi and bacteria), including rhizobia, and soil amendments (such as lime and biochar) can enhance nutrient availability, improve soil characteristics and bolster crop health. By ensuring soil health and thus soil responsiveness through the above-mentioned measures, thoughtful and strategic use of inorganic fertilisers can target specific nutrient deficiencies while providing readily available nitrogen, thereby enhancing both yield and soil health.

Open dumping of organic and other wastes in Ghana. Photo: Pierre Ellssel

Current status of off-farm produced organic fertilisers

To understand the current state of off-farm organic fertilisers, soil amendments, and biofertilisers (biostimulants) in Africa, a scoping study was conducted across twelve African countries. This included a desktop review of existing literature, own calculations and interviewing 89 key informants across the organic and biofertiliser value chain. The countries spanned all African regions: Egypt (North), Cameroon, Côte d'Ivoire, Ghana, Senegal (West/Central), Ethiopia, Kenya, Rwanda, Uganda (East), and Malawi, South Africa and Zimbabwe (South).

In Africa, the production and use of off-farm produced organic fertilisers and soil amendments are still in their early stages. In many countries, organic waste recycling lacks policy prioritisation, often due to non-existent policies, inadequate enforcement or unfavourable incentives. Currently, with some exceptions, only a small fraction of organic waste is being processed into organic fertilisers or soil amendments across the twelve case study countries. In South Africa, some communities are currently diverting up to 50 per cent of organic waste from landfills. The country formulated a National Organic Waste Composting Strategy in 2013. Nigeria has one of the highest production capacities, at about 500,000 tons/year, yet only 50 per cent of this capacity is currently utilised. Egypt is home to one of the largest single producers, with a production capacity of 120,000 t/year. Key organic waste streams include household food and green waste, market waste, agro-processing residues, and human excreta. These are processed into compost or liquid organic fertilisers. Non-source segregated organic waste composts typically contain nutrient levels below one per cent for nitrogen (N), phosphorus (P) and potassium (K), serving primarily as soil amendments. Higher nutrient values are achieved through waste sorting and treatment with biodigesters, black soldier flies (frass fertiliser) or worms (vermicompost). Co-composting household or agricultural waste with human excreta can also boost nutrient content, but outcomes vary depending on various factors. Sometimes, composts are enriched with chicken manure or inorganic fertilisers to elevate nutrient concentrations.

"Various existing technologies are effective, but the challenge lies in producing a high-quality product and implementing policy measures that encourage farmers to utilise them. The primary concern is not the technology itself but the entire value chain, from

sourcing waste as a resource to delivering the final product to the market. This includes considerations of waste quality, related issues affecting waste quality, and the logistical challenges in waste collection and treatment." *(International consultant)*

Economic sustainability and pricing of organic fertilisers

Generally, we found that companies with access to knowledge, finances, technology and supportive local municipalities – such as those providing land close to waste streams – are key factors for success. Specifically, the involvement of international donors and/or research institutions played a crucial role for some companies. Additionally, active engagement with farmers and the establishment of field demonstrations are key success factors.

"We are profitable largely due to the scale that we operate at, with our largest costs being feed stock, the purchasing of organic materials and transporting it to our site. There isn't high quality enough equipment that matches what we need domestically, so we import it. The same for spare parts. And then you pay at least 30 per cent import tax on a vehicle that's assembled outside of the country. The biggest challenge was to convince and educate farmers on the importance and usefulness of the product [fortified compost]." *(Organic fertiliser producer, Kenya)*

Prices for organic fertiliser exhibit great variations across countries, ranging from 0.72 euros to 65 euros for 50 kg, respectively. In Senegal, one ton of inorganic NPK (nitrogen, phosphorus, potassium; 15:15:15) fertiliser was priced at approximately 800 to 1,100 euros (2023). To match the nutrient values of this fertiliser, one would need about four to five times the amount of a compost fortified with chicken manure and phosphate with NPK (4:3:3), which was priced at about 300 euros/t in Senegal. However, conducting such a simplified calculation may not account for all relevant costs and benefits, such as potential improvements in soil health, micronutrients and different levels of soil responsiveness to different types of fertilisers.

Potential supply of macronutrients from wastes

There is high potential for the (re)circulation of organic matter and its nutrients. In many contexts, substantial amounts of organic matter and nutrients could return to agriculture if systems were appropriately designed or adjusted.

"If you were really restructuring the system, you could meet between 20 per cent and 40 per cent of the nutrient requirements of an agricultural system within a specific boundary. In most cases I'm comfortable saying that somewhere around a quarter of the nutrient needs could be met through recycled nutrients." *(Researcher, ETH Zurich)*

Human excreta contain significant amounts of nutrients that, if captured, could contribute about 28 per cent of the world's current NPK consumption in agriculture or 22 per cent of global phosphorus demand. The potential for nutrient recirculation from human excreta is substantial, especially in sub-Saharan Africa, where 80 to 95 per cent of the population use onsite sanitation systems that require regular emptying. Unlike sewage systems, septage from on-site sanitation systems is generally not contaminated with heavy metals, and co-composting can effectively eliminate pathogens.

When assessing the theoretical nutrient potential present in human excreta across the twelve case study countries, the estimated nutrient quantities amount to approximately 3.4 million t/year of NPK. In comparison, the total agricultural consumption of inorganic fertilisers (NPK) in these countries reached 3.6 million tons in 2019. Additionally, the collection and recycling of household food and green waste could theoretically recover 71,000 t/N year, 71,000 t/P year and 141,000 t/K year across the twelve African countries (see Figure). In theory, the combined human excreta and household food and green waste produced in the case study countries could match the current NPK consumption. However, it is important to note that the current inorganic fertiliser application rate in Africa is low, at about 20 kg/ha. Under practice conditions, and after including potential losses, the contribution of NPK from off-farm produced organic fertilisers could be between 50 and 80 per cent of current inorganic fertiliser consumption.

Market wastes, slaughterhouse residues and other agro-processing by-products are additional sources. However, data on these wastes are limited. A study by the UN Food and Agriculture Organization (FAO) estimated that Ethiopia has about 1 million t/year (dry matter) of unused agro-processing by-products. Assuming a nutrient content of about 1 per cent, depending on waste type and treatment process, this translates to an estimated 10,000 tons of NPK.

In addition to the recirculation of macronutrients, the value of adding organic matter and micronutrients from recycled organic wastes should also be considered.

Current status of production and use of biofertilisers

The term "biofertiliser" (biostimulant) refers to a diverse array of microbial-based products incorporating plant teas, mycorrhizal fungi and beneficial bacteria, including nitrogen-fixing and phosphate solubilising bacteria. Biofertilisers can stimulate plant nutrition processes, are used as plant strengthener to enhance plant defence mechanisms, and indicate potential for yield improvements, specifically in dry and tropical climates, and carbon and nutrient poor soils.

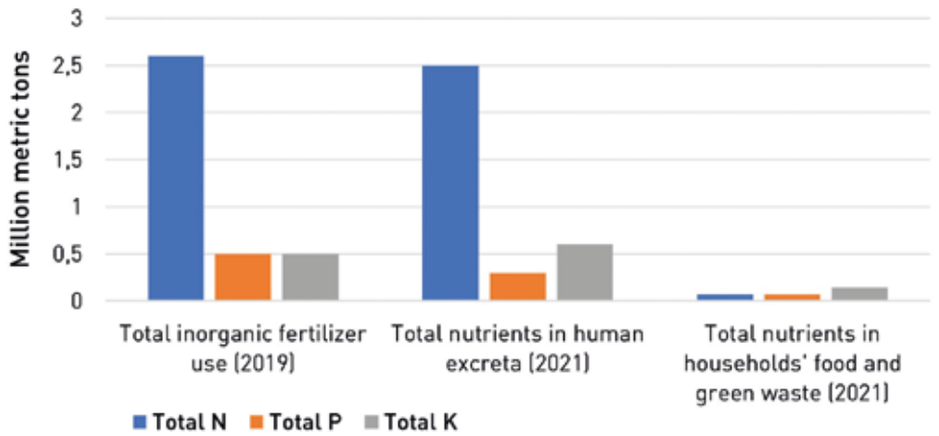
"According to our research, as well as by [research of] others, the yield of many crops increased by 16 per cent to 52 per cent when these crops received the recommended doses of biofertilisers." *(Researcher, Heliopolis University, Egypt)*

Of the global production of biofertilisers, products with N-fixing properties account for about 80 per cent, those with P-solubilising properties for 14 per cent and others for 6 per cent. The global market share of biofertilisers in Africa is estimated at about 5 per cent. The most advanced market in Africa for biofertilisers and producers can be found in South Africa. Egypt, Kenya, Malawi and Zimbabwe seem to exhibit a more advanced level of production and usage, primarily relying on rhizobia-based products. In contrast, Central and West Africa are the least developed regions in terms of production and usage. However, most of the biofertilisers marketed in sub-Saharan Africa are imported, and their product quality is often deficient.

One of the challenges regarding rhizobia production and use is the lack of access to modern technology. One exception is a company in Malawi, currently producing rhizobia for 50,000 ha. Further, consistent standards and quality control are lacking in many countries, which are crucial for consumer trust and hence increasing market shares. Most of the case study countries have introduced initial policies for organic and biofertilisers. However, these policies are often insufficiently comprehensive and are only partially implemented and enforced in practice.

"Quality standards and testing are missing. And enforcing the standard is what is more import-

Current application of NPK via inorganic fertilisers and total nutrients potentially available in human excreta and household waste across 12 African countries



Own calculation, figures are rounded; population data: World Bank (2021); total agricultural use of inorganic fertilisers (oxide forms converted to amount nutrient: N, P, K) from FAOSTAT (2019); human excreta according to Rose et al. (2015); household food and green waste data from Kaza et al. (2018); low anticipated average nutrient contents in compost N (0.5%), P (0.5%), K (1%) (e.g. Kabasiita et al., 2022).

ant because to have a standard that you don't enforce is as good as if you didn't have a standard. There are many products spilling in [from outside Africa] but you don't know if the product is tested, if it is good, if it is really working. So, they might sell it for a low price which finally affects the development of good products which might cost more but work in the end." *(Biofertiliser/rhizobia producer, Malawi)*

Challenges in biofertiliser application include limited understanding about storage, dosage and application technology, resulting in uncertainties and variable outcomes. Microbial contaminants are common problems influencing the quality of biofertilisers; hence the properties of carrier materials need to be well maintained to secure shelf life and, ultimately, product quality. Issues stem from incomplete knowledge of bacterial multifunctionality, complex interactions in soils and varying responses to biotic and abiotic factors. Technical challenges in formulation and inconsistent practical results are further important obstacles. However, as research and development continue, biofertilisers may play an increasing role in agriculture.

Key opportunities for scaling

The future potential of off-farm produced organic and biofertilisers appears promising for improving soil health and crop yields, reducing environmental pollution and human health burdens, and creating employment opportunities and additional income. To foster the potential for scaling, several key areas need to be addressed:

Policies, regulations and standards

- Institutionalise waste management through recycling policies, laws and regulations.
- Ensure policy consistency and cross-sector coordination: waste, sanitation, agriculture.
- Develop clear and unambiguous policies to permit and guide the safe application of fecal sludge (e.g. as co-compost) in agriculture.
- Create coherent standards and quality monitoring for organic and biofertilisers. Verified products with a constant quality and reliability are needed to gain consumer trust and hence foster market growth.
- Harmonise standards across countries to foster trade and create a favourable business environment.
- Collect regionalised source specific biomass data.
- Provide guidelines on the hygienic treatment of human excreta-based fertilisers and household waste.
- Support collection (reduce costs for entrepreneurs, decentralised production) and incentivise waste segregation in the context of private-public partnerships.
- Increase incentives by implementing blended finance, favourable interest rates, reduced import taxes and subsidies equivalent to those for inorganic fertilisers – among others.
- Reduce and optimise bureaucratic procedures, especially for small enterprises and start-ups.
- Municipalities can support entrepreneurs through the provision of land for processing.
- Municipalities can provide gate fees to treatment facilities for their services, just as they do for landfill management, to support waste management and ensure cost coverage for the treatment facility.

Economy and markets

- For any economic assessments, internalise external costs of lacking waste management (pollution, public health, etc.); and incorporate the value of other nutrients and the carbon.
- Foster business thinking – focus on both landfill reduction and the fertiliser market needs.
- Build on existing inorganic fertiliser market channels and also ensure affordable prices for smallholders.

Research, education and training

- Test optimal combinations of inorganic and organic fertilisers, soil amendments and biofertilisers combined with forage legumes/multipurpose legumes and alley cropping.
- Conduct systematic research on bacterial and fungal inoculants and optimal combinations.
- Intensify rhizobia research for all legume species; develop a forage legume seed market.
- Build awareness: establish advisory services, teaching and training on organic and biofertilisers.

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The full study report and a knowledge brief can be accessed at: https://www.desiralift.org/resources/

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